EXTRACTIVE FOREST PRODUCTS AND AGROFORESTRY ON AN AGRICULTURAL FRONTIER: A CASE STUDY WITH THE PARAKANÃ TRIBE OF THE TRANSAMAZON REGION, PARÁ, BRAZIL

By

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By

Robert Pritchard Miller

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In Brazil, and especially in the Amazon Basin, indigenous reserves occupy large tracts of tropical forest and savanna ecosystems, and they will play an increasingly important role in the conservation of biodiversity. Indigenous communities are moving from traditional, non-monetary subsistence economies to full participation in national economies, through the sale of crafts, extractive forest products, agricultural products, or through wage labor. This dissertation examines the issues and opportunities created by this economic transition with regard to a particular indigenous group, the Parakanã of Pará State. Two principal topics are explored: (1) the Parakanã's participation in the regional economy and (2) the potential for incorporating agroforestry into their farming system as a source of income.

The study of the Parakanã's economy looks first at their subsistence agriculture and use of natural resources, then examines their participation in a regional economy through the sale of agricultural and extractive forest products. Non-timber forest products were found to be an important component of the Parakanã economy; however, important differences were found in the choice of items being marketed by the different villages, with access to reliable transportation and perishability being important factors in this choice.

The potential of agroforestry as a source of income for the Parakanã was explored through an experiment consisting of the establishment of small-scale plantations of fruit trees within their traditional, low-input agricultural system. This experiment monitored the growth of assorted fruit trees in slash-and-burn agricultural fields and villages over a period of two years, using various parameters of tree growth (height, diameter, leaf number, and crown volume) as indicators of the trees' ability to compete with successional vegetation. All species did best in the open environments of the villages. Coconut (*Cocos nucifera*) and soursop (*Annona muricata*) did very poorly in field environments. While cupuaçu (*Theobroma grandiflorum*) grew best in the open environments, it had reasonable growth in shaded field environments, especially when planted in new banana groves. Given the characteristics of the Parakanã's agricultural system, only shade-tolerant trees such as cupuaçu are recommended for planting in fields.

However, planting fruit trees around dwellings in the form of home garden agroforestry systems can contribute to the community's food supply.

CHAPTER 1
GENERAL INTRODUCTION

Introduction

Indigenous communities are the guardians of large tracts of forest and savanna ecosystems in the Amazon Basin and they will play an increasingly important role in the conservation of biodiversity as we enter the new millennium. Their reserves, the greater part of which are in Amazonia, account for approximately 12% of Brazil's territory (Fig. 1-1). How these communities choose to manage their natural resources will depend to a great extent on the nature of their economic relationships with the surrounding national society. Today, many indigenous communities in Amazonia are moving from traditional, non-monetary subsistence economies to full participation in a national, if not global economy, whether through the sale of crafts, extractive forest products, agricultural products, or through wage labor. This dissertation examines the issues and opportunities created by this economic transition with regard to the situation of a particular indigenous group, the Parakanã of Pará State, Brazil (Fig. 1-2).

Two principal topics are explored in this dissertation: (1) the Parakanã's participation in the regional economy and (2) the potential for incorporating agroforestry into their farming system as a source of income. Although a significant portion of the research carried out for this dissertation involves an agroforestry experiment, the dissertation will not use the conventional format associated with the presentation and

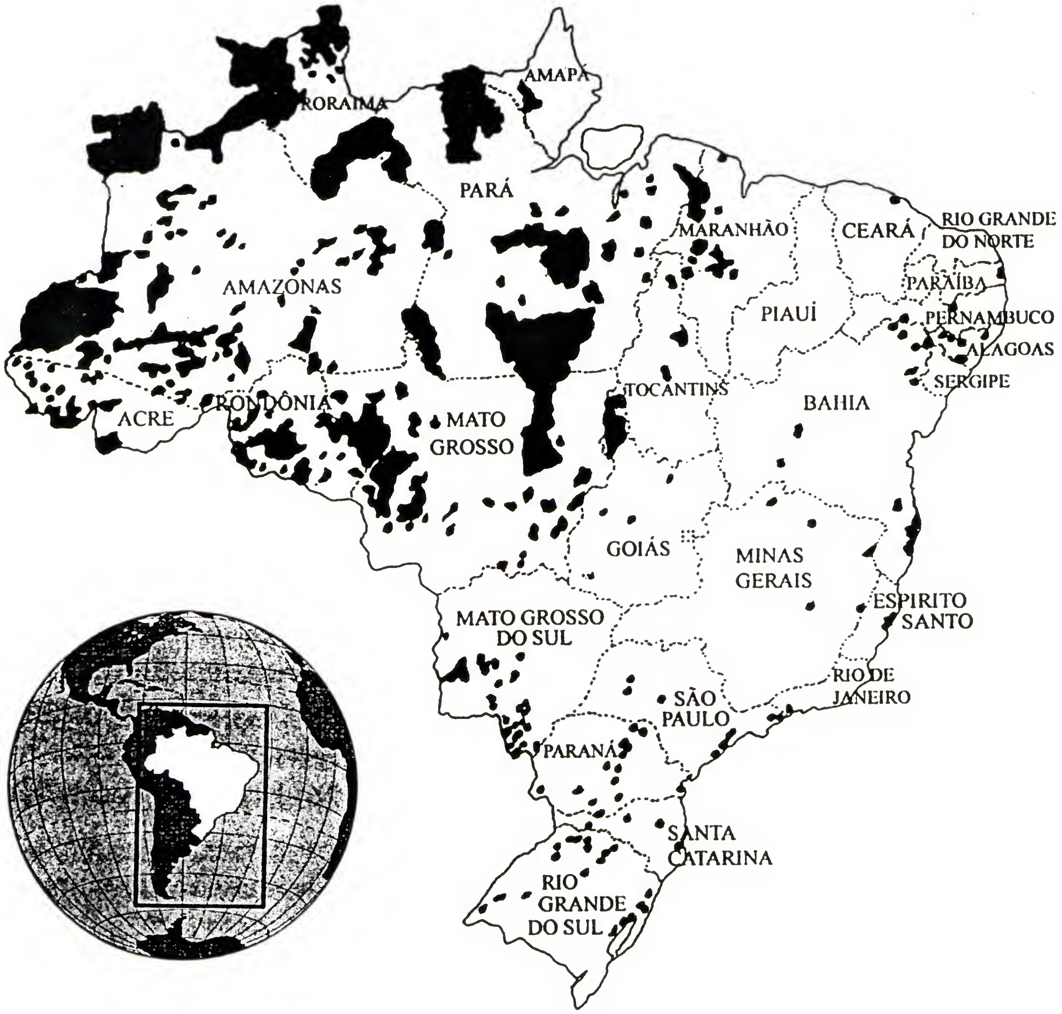

Figure 1-1: Location of indigenous reserves in Brazil. Includes both officially demarcated reserves and areas pending demarcation. Adapted from Instituto Socioambiental (2001).

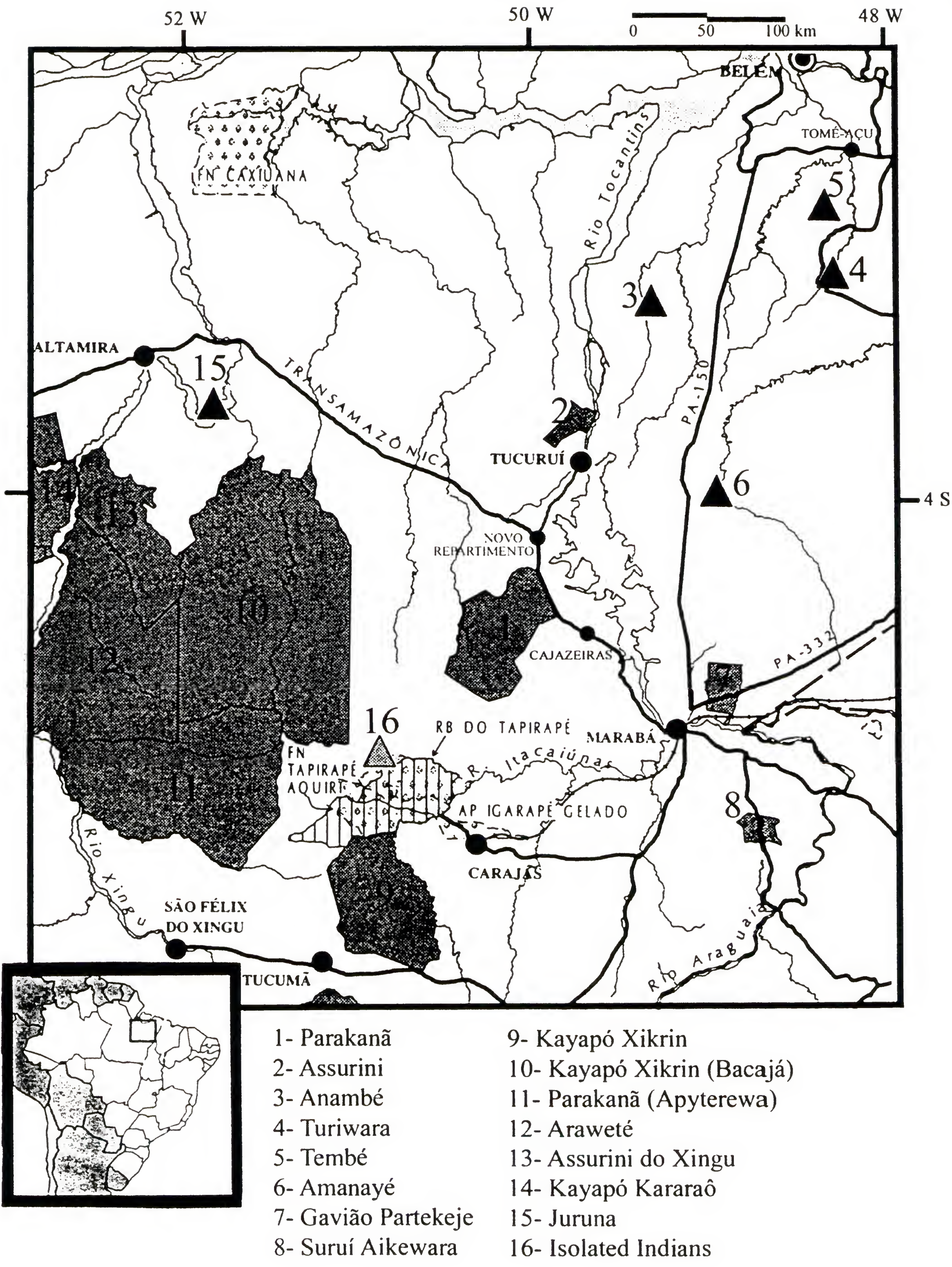

Figure 1-2: Location of the Parakanã Reserve, other indigenous reserves and geographical features in southeastern Pará, Brazil. Adapted from Instituto Socioambiental (1995).

testing of hypotheses, namely, an introduction, materials and methods, results, and discussion. Rather, the initial chapters (Chapters 2 and 3) will cover topics related to the broader themes of the dissertation. The following chapters (4 and 5) will take a somewhat ethnographic approach to looking at the Parakanã's history, political structure, and economy. While Chapters 5 and 6 cover the specific research results, they will also explore the significance of these findings within a broader picture. Chapters 7 and 8 bring together the results of the previous two chapters and examine their relevance to both the Parakanã and settlers in the Transamazon Highway region. In brief, following a general introduction to the dissertation (the present chapter), the sequence of chapters and their themes will be as follows:

- Chapter 2 discusses the history of contact of indigenous peoples with Brazilian society, and some of the difficulties which threaten their survival as communities. A discussion of the socioeconomic impacts of contact then provides the basis for examining the current status of indigenous communities *vis-a-vis* the market economy, as well as the ambiguous record of agricultural extension projects as a means of community development.
- Chapter 3 reviews traditional agroforestry systems in Amazonia, from prehistory to the present day. One of the assumptions of this dissertation is that for indigenous communities, agroforestry systems may provide a more realistic way to incorporate income-earning crops into their traditional agricultural systems and lifestyles. This discussion of traditional systems, therefore, provides the backdrop

for exploring the applicability of agroforestry extension for indigenous communities, and for frontier settlers today.

- Chapter 4 takes a closer look at the study site and the Parakanã tribe, looking at its history, political structure, and the physical characteristics (rainfall, vegetation and soils) of their Reserve.
- Chapter 5 examines the Parakanã's economy, with an overview of both subsistence and commercially-oriented activities. Special attention is given to the role of extractive forest products as a source of income, and how their harvesting fits in with other activities such as hunting, fishing, and subsistence and commercial agriculture. Comparisons are made between the Parakanã's use of non-timber forest products and that of neighboring ranchers and settlers, and the potential role of these products as elements for forest conservation is discussed.
- Chapter 6 presents the results of an agroforestry experiment carried out in two Parakanã villages to test the adaptability of indigenous practices of fruit tree cultivation to larger scale, commercial operations. The growth response of four species of fruit trees planted in slash-and-burn agricultural fields and around dwellings was compared and evaluated in order to determine optimum planting sites. For selected species, an additional comparison was made of the relative benefits of low-input planting methods (no fertilizer) versus methods using locally available fertilizers.
- Chapter 7 brings together the results of Chapters 5 and 6 to examine the potential for including agroforestry systems in the Parakanã's agricultural and extractive economy. In sequence, and returning to some of the issues raised in Chapter 2,

the role of the Programa Parakanã as an aid program and agent for community development is discussed.

- Chapter 8 returns to the broader themes touched on by this dissertation and discusses the potential applications for agroforestry in the Transamazon region, with specific regard to the issues of forest conservation policy, agricultural extension and carbon sequestration.
- Chapter 9 presents a synthesis of the research findings and summarizes their potential application for the Parakanã and small-scale farmers.

Choosing the Study Site

In September 1997 I visited the Parakanã community of the Parakanã Indian Reserve in Pará, Brazil, following up on a long-standing invitation by José Porfírio Carvalho, advisor for indigenous affairs to Eletronorte.[1] Since 1987, Eletronorte has funded an aid program for the Parakanã to mitigate the social and environmental impacts caused by the Tucuruí Hydroelectric Dam on the Tocantins River. During that visit, a combination of characteristics were observed which made the Parakanã Reserve an appropriate choice as a site for an agroforestry research/extension project. These were the following:

- Existing relationship of the Parakanã with a market system, in which agricultural and extractive products are marketed, justifying investments in fruit trees for commercial production;
- Apparent lack of tradition of planting fruit trees, which, theoretically, could make new technologies of fruit tree cultivation of interest to the community;

---

[1] Centrais Elétricas do Norte do Brasil, S.A., the regional power company

- Nutritional problems, especially among children, which could be partially alleviated by increased production of fruit for community consumption.

An additional factor in this choice was the commitment by part of the Programa Parakanã to provide logistical support for field activities. The Programa Parakanã, the result of a cooperative agreement between FUNAI[2] and Eletronorte, provides assistance in the areas of health, education, protection of reserve boundaries, and transportation and marketing of products. As such, agroforestry extension is relevant to its general goals, and when a proposal for a project of that nature was presented to the Programa Parakanã, it was readily accepted.

---

[2] Fundação Nacional do Índio, the agency responsible for the welfare of indigenous peoples in Brazil.

CHAPTER 2
INDIGENOUS COMMUNITIES, MARKET ECONOMY, AND AGRICULTURAL EXTENSION PROJECTS IN BRAZIL

This chapter examines how indigenous communities in Brazil have made the transition from non-monetary economies to different levels of integration with local and national economies. Relevant literature on different ethnic groups is reviewed in order to develop an understanding of the general trends or patterns which govern this process and to identify the factors which influence interaction with surrounding society and markets. Specific attention is given to how this process has been affected by ideologies of development. Community development projects which seek to integrate Indians into regional economies are analyzed in terms of their impacts on social structures and relationships within indigenous communities.

Introduction

An increasing global awareness of the importance of biodiversity and tropical rainforests has been accompanied by the increased concern for the rights and well-being of traditional forest-dwelling peoples. The social norms of forest peoples often support conservation practices, and they may have important contributions to make towards sustainable development (Forster and Stanfield 1993). However, the stability of such communities is tied to their ability to carry out subsistence activities and fulfill their basic needs. This very often requires the use of manufactured goods, such as steel tools, implements, fish hooks, powder, shot, and salt, which can only be obtained through exchange relations with external markets. In these economic relationships, labor embodied in the form of goods extracted from the surrounding natural environment or agriculture is exchanged for manufactured items or cash. Upon entering into economic relationships with surrounding national societies, indigenous communities initiate a process with serious implications for the continuity of their own non-monetary economies as well as their social structure. The nature of these transitions to new economic relationships, along with their implications for the social structure and community well-being of indigenous societies, is therefore a very relevant issue for Brazil today, and raises some key questions as to the processes involved:

- What draws indigenous communities into economic relationships with outsiders?
- What are the products being exchanged?
- At what point does the market begin to organize the economic life of the community?
- How is this process conceptualized, both by indigenous peoples as well as by dominant ideologies?

This chapter will explore some of the theories which have been advanced to explain the above processes and will also look at how officially sponsored community development projects fit into the story.

General Situation of Indigenous Communities in Brazil

The level of complexity of economic exchange can be used to describe the relationship which indigenous communities have with surrounding society. For example, based on levels of economic exchange, Junqueira (1991) places indigenous groups in Brazil in three broad classifications:

- Autonomous or isolated groups, with no contact with the dominant society;
- Groups with sporadic contact, living in regions exposed to occupation by outsiders, and maintaining some degree of relationship with a market economy;
- Groups with regular contact, and which depend heavily on goods produced by a market economy.

These classifications are extremely broad, and indigenous communities can be further described according to a number of criteria such as ecological region, type of agriculture, history of contact, language family as well as a number of cultural and socioeconomic characteristics.

Price (1989: 12) expands on Junqueira's classification, explaining it as a model in which the distinguishing operative variables are political and economic: "uncontacted Indians are politically and economically independent; Indians in intermittent contact have established a trading relationship, and are economically dependent but retain political autonomy; Indians in permanent contact have lost both their economic and political independence; and integrated Indians have lost their identity."

Around fifty indigenous groups still exist in isolation in Brazil (A. Kesselring, personal communication [pers. comm.], 1994). Most consist of small bands that may be remnants of once larger groups, decimated by disease, violent contact with expanding frontier or extractivist activities, or wars with other tribes. While in the past, the "attraction" and "pacification" of isolated (and often bellicose) groups was one of the main concerns of Indian policy in Brazil, current FUNAI policy is to leave them alone and restrict interventions to the protection of their territory, unless there are unavoidable risks to these groups as a result of expansion of national society. However, for most indigenous groups the general tendency following contact with Brazilian society has been of greater sedentarization leading to economic dependency (Paiva and Junqueira, 1985). While an expanding national society may force groups into a greater degree of contact and economic exchange, FUNAI has also actively pursued programs with the intent of bringing communities into a closer relationship with market economies. These programs will be discussed in depth in later sections of this chapter.

The ethnic groups which live in more remote regions of Amazonia often do not suffer any appreciable shortage of land on which to practice their agriculture and engage in hunting or fishing to procure protein. However, this is not necessarily the case for ethnic groups in other regions. The Kanela of Central Brazil, for example, have been forced to shorten their fallows of cultivated areas because of a reduced land base. As a result, the soils which they cultivate do not have time to recuperate their fertility and therefore produce low crop yields (Flowers et al., 1982). A similar problem with land and resource availability was described by J. Carvalho (pers. comm., 1995) for the Guajajara of the State of Maranhão, Brazil, where the shortage of resources on some reserves has reached the point where even the palms which they use to thatch their houses are in short supply. According to Sampaio (n.d.: 31), 85% of the Amerindian population of the Northeast Region of Brazil has problems of hunger and malnutrition. Difficulties encountered by indigenous communities are not only limited to questions of subsistence and livelihood, but also include problems such as land invasions, cultural loss, alcoholism, health problems, and illegal logging and gold mining.

Although there are many similarities between indigenous communities and non-Indian rural populations, especially in terms of their agricultural practices and natural resource use, there are also important differences. In comparison to regional populations, the sociocultural milieu of indigenous communities often implies

- tighter knit communities and decision-making
- communally held property
- communally managed resources
- different goals
- different relationship with surrounding society
- different cultural history
- own language/bilinguality.

Increasingly, however, the distinctions between indigenous communities and the small-scale farmers of the region cannot be treated as a sharp dividing line but rather as a gradient. In the state of Amazonas, for example, many Tukano Indians have migrated out of the Upper Rio Negro region to establish themselves near the city of Manaus, where they may live as small communities or as single families (pers. obs.). In this last case, in socioeconomic terms they differ very little from the surrounding agriculturalists. Galvão

(1979) describes this as a generalized process occurring along the Rio Negro for individuals of many different ethnic groups. Along the Andirá River, on the border of Pará and Amazonas States, the Sateré-Maues Indians display a gradient of dependency on the outside world which diminishes according to the distance from the mouth of the river, their principal contact with Brazilian society (A.B. Freire, pers. com., 1995).

Unlike the situation for peasants in many rural regions, as described by Plattner (1989), for many indigenous communities in Brazil the market is a foreign place in terms of location, language and culture. The Indian is at a distinct disadvantage and is unfamiliar with its rules and customs. There are, however, exceptions to this statement. In Tabatinga, a town on the Brazil/Colombia border, Tikuna women can be observed taking agricultural and craft goods for sale in the market. However, the Tikuna are the second largest indigenous group in Brazil, numbering approximately 10,000, and have a strong presence in the region of Tabatinga. Another example of Indians who seek out urban markets for trade is the Yekuana, known in Brazil as Maiongong. The Yekuana have historically engaged in epic trading voyages, from the headwaters of the Orinoco to the mouth of the Essequibo on the Caribbean (Guss, 1989), and this tradition of trading voyages continues today, albeit over smaller distances. Yekuana living in Brazil regularly make trading trips down the Uraricoera River to reach Boa Vista, the state capital of Roraima, a voyage of several hundred miles (pers. obs.). Their principal item of trade was, until recently, their very large dugout canoes. For most indigenous communities, however, the most common form of exchange for goods is not through marketplaces, but through intermediaries. In much of Amazonia, this intermediary is the ubiquitous "regatão" or river trader who travels up and down even the remotest rivers, purchasing agricultural and forest products, and selling or exchanging manufactured items. How this exchange activity is linked to larger economic systems will be discussed later on in this chapter under the section "Indigenous Communities and Larger Economic Systems." First, however, the following section will discuss some aspects of the official ideology and policy relating to indigenous communities.

Official Ideologies and Indigenous Communities

Not long after the first arrival of Europeans, official positions of the colonial government towards the indigenous inhabitants of Brazil were established through decrees and administrative directives. As the neo-Brazilian population became a majority, government policies towards Indians changed according to shifting political and philosophical currents. It is important, however, to distinguish government policies from the actions of private citizens, companies, or of local governments. At times, government policies were amenable to the desires of economic interests and at other times in conflict. The creation of the Serviço de Proteção do Índio (S.P.I.) in 1910, while having as one of its goals the pacification of indigenous groups which blocked national expansion, represented a milestone in the official treatment of Indian affairs. This federal agency was formulated according to the principles of a group led by Marshall Cândido Rondon, who laid over 1000 km of telegraph lines in the hinterlands of Brazil, and developed a non-violent method of contacting Indians and moving through their territories. Rondon and his contemporaries based Indian policy on the ideas of the positivist philosopher Auguste Comte. The humanistic ideals of the founders of the S.P.I. postulated that indigenous communities, once freed from external pressures, and with the aid of the government, would evolve spontaneously to the point where they could become integrated into the agrarian economy of the nation (Ribeiro, 1962). Over time, however, the S.P.I. succumbed to political and economic pressures, becoming so riddled with corruption that the Brazilian government was forced to extinguish it, replacing it with FUNAI in 1968.

Despite the apparent concern for the the cultural values and lifestyles of indigenous groups, the Estatuto do Índio (the law establishing Indian policy) of 1973 called for a progressive integration into national society, and did not protect Amazonian Indians from the systematic assault on their rights that occurred in the 1970's and 1980's. However, this hostility to Indian rights resulted in a major policy struggle between the military and a more vocal and mobilized civilian society (Schmink and Wood, 1992). One of the results was that the new Brazilian Constitution of 1989 shifted the emphasis of Indian policy from "civilization" and "integration" to the recognition and respect for the traditional lifestyle of indigenous groups (Maia, 1993). However, despite protective legislation and the existence of a civilian government, indigenous groups continue to be subject to a variety of pressures by those who covet the natural resources found on their lands.

In recent years, the return to a civilian government has been accompanied by apparently positive changes in FUNAI. In contrast to the institution which Price (1989: 159) described in 1980 as "dominated by colonels with prior experience in public opinion management and in cahoots with security agencies," several of the recent directors, such as Julio Gaiger, and as his predecessor, Márcio Santilli, are individuals who have been involved in working for indigenous rights. As a result, overall policy of FUNAI has changed a good deal, in returning to a stance which is sensitive to the rights of indigenous communities to maintain their ethnic and cultural identity, and in recognizing that this identity is key to their survival as autonomous and self-sufficient peoples. However, despite changes in policy and personnel, FUNAI remains plagued with inefficiency and corruption. FUNAI faces serious problems in administering to an estimated 330,000 Indians, who exhibit varying levels of acculturation[3], health needs and territorial problems, and who often live in an environment of hostile neighbors and political powers.

Indigenous Communities and Larger Economic Systems

The expansion of market-oriented societies into the traditional territories of indigenous groups can, to an extent, be explained by the demands created by external markets for natural resources or goods which can be produced from these lands. This was the case in the past for such goods as rubber and Brazil nuts, and more recently, for gold, as seen in the well- publicized invasion of the lands of the Yanomami by gold miners. In recent decades, the process of expansion into Indian lands, while fueled by prospects of economic gain, was also justified by an ideology of modernization. Modernization theory was a central underpinning of much of Brazil's economic and development policy in recent decades, and had grave impacts on indigenous communities in the 1970's and 1980's. During this period of military government, the interests of development and national security called for the modernization and incorporation of Amazonia into the national economy, by means of a number of large projects, such as roads, dams and railroads, and the rights of indigenous groups were relegated to a minor plane. The impacts of these mega-projects on indigenous communities is discussed in depth by Shelton Davis in his book *Victims of the Miracle* (1980). The effect of a single such project, a World Bank-funded highway construction project in Rondônia, is addressed in David Price's *Before the Bulldozer* (1989). The impact of hydroelectric projects on indigenous communities is discussed in Cummings (1990). Although present-day Indian policy has attempted to steer away from modernization as an ideological basis, and FUNAI is now under the auspices of the Ministry of Justice, very few indigenous lands are not threatened in some way, directly or indirectly, by national expansion.

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[3] Acculturation signifies the absorption of a culture other than one's own.

The assault on indigenous lands is not restricted to the actions of large enterprises (such as mining and logging companies and ranchers), or development projects, but also involves the invasion of reserves by landless agriculturalists and collectors of forest products. Although it could be argued that small-scale agriculturalists are merely trying to gain control over means of production to which access has been restricted in other locales, these encroachments do not represent capitalism per se, and it is perhaps more useful to look at other formulations or explanations of economic relations. To use a Marxist economic analysis, it can be said that to the extent that these agriculturalists and gatherers of forest products engage in an essentially subsistence-level lifestyle, they are not full participants in a market system but rather, marginal participants of a periphery. The linkage between the periphery, constituted of rural inhabitants (including indigenous communities), and the industrialized and highly urban southeast of Brazil (the country's economic core) occurs through the exchange of agricultural or forest products, such as rubber, or seasonal wage labor on enterprises such as large farms or ranches.

For those who occupy such a periphery, major aspects of economic, social and cultural life cannot be explained in terms of what goes on in the core (Roseberry, 1989). Rural communities and their economies are often enmeshed in kinship and social systems, and survival and reproduction still depend very much on the adherence to a system of symbols which are not transmitted or codified by homogenizing media images which are typical of life in large urban centers.

Where indigenous societies without a tradition of monetary exchange are only beginning to establish or consolidate market relations and coexist with more modern economies, it is possible for communities to exist outside of even the periphery. In order to understand the impacts of economic transitions on such communities, we need to look closer at the margins of the periphery, and go beyond the core-periphery model which is used to explain regional and national economic relations.

According to Galvão (1979), in order to understand "acculturation" or cultural change in indigenous groups, studies must also include the non-Indian communities of the region, in an analysis of the interaction of cultural configurations. This concept of interaction between cultural configurations is similar to the model of articulation of the modes of production, which was developed to explain the dynamics involving the coexistence of non-capitalist systems of production and capitalist market systems in Africa (Dupré and Rey, 1980). In this model of the various levels of capitalist domination and their interaction, it is possible to have situations in which the capitalist mode of production may play no part in a group's social formation, yet domination can take place through trade, if the group is dependent on outside goods for its social reproduction. This system may co-exist with a neo-colonial mode of domination, in which traditional modes of production give way to small commodity or capitalist production (in the form of plantation economies). Intermediary situations between these two levels of domination may also exist, and in fact, the presence of goods trade based on a limited access to surplus labor may actually help in maintaining a traditional system.

The interplay of modes of domination which Dupré and Rey (1980) observed in Africa is relevant to the situation of indigenous communities in Brazil, where exchange relationships with a larger economy are generally initiated by trading agricultural or forest products for manufactured items. At times, FUNAI has provided assistance in attempting to organize such trade in order to avoid exploitation of the indigenous communities. However, in many instances, FUNAI has had to compete with local merchants, traders and poachers for the attention of the Indians. According to Fisher (1994), even today FUNAI is often at a disadvantage, as it cannot offer the long-term traditions of reciprocity and patronage which merchants or traders are accustomed to offer to their clients. The high rate of turnover of FUNAI employees, institutional instability, and the absence of adequate programs for livelihood improvement are also factors which lead indigenous communities to seek economic relationships outside the tutelage of FUNAI. This has been the case of the Kayapó in the state of Pará, who have chosen their own style of development, by permitting gold mining on their lands and charging miners for a percentage of their revenue, and by selling mahogany. However, this has not occurred without cultural and environmental impacts (Rabben, 1998). Also in Pará, the Gavião-Partekeje have rejected the economic tutelage of FUNAI and have managed their own sales of Brazil nut harvests (Arnaud, 1989), and, more recently, harvests of açaí and cupuaçu fruits (pers. obs.). Compared to the Kayapó, their economic independence has had a minimal effect on the sustainability of their environment and future resources. However, the forest of the Gavião reserve is rich in various non-wood products, and their proximity to the city of Marabá greatly facilitates the commercialization of these products. Nevertheless, examples of such levels of managerial expertise are not always the norm, and many indigenous communities are at a distinct disadvantage in exchange relationships, as they often have a poor grasp of numbers and monetary values, and as a result, receive low compensation for their products or the resources of their reserves.

The following section will examine various theoretical approaches to explain the factors involved in the transition to greater involvement with surrounding market economies. This will then provide background for analyzing the effects of community development projects on indigenous societies.

Theoretical Approaches to Understanding Indigenous Communities and Economic Relations

Along with ethnological questions, anthropologists in Brazil have also been profoundly concerned with the topic of acculturation. Acculturation, in its simplest definition, is what occurs when one society accepts the customs of another (Price, 1989). For the Brazilian Indian, acculturation and increasing linkages with market economies appear to be two sides of the same coin, in that they are processes which commonly occur simultaneously. According to Galvão (1979), while direct and continuous contact of indigenous groups with rural populations is necessary for acculturation, in a strict sense, the process begins long before that, with the introduction of metal tools, the shrinking of hunting and gathering territories, the decline in population due to diseases, the modification of social status and prestige due to the aquisition of new objects, and finally, the disorganization of social institutions.

To the extent that primitive economies and social systems are enmeshed, the weakening of the social institutions of an indigenous community would appear to be a necessary prerequisite for acculturation and adherence to new economic relationships. However, to the extent that psycho-social phenomena can be separated from purely economic behavior, it may be possible to study the process of acculturation separately from the movement into market economies. Basically, it will depend on where one draws boundaries, and where one wishes to lay causality. Gross et al. (1979) postulated that a community's degree of market participation is not directly a result of the frequency of contact, but is instead related to the difficulty in making a living from slash-and-burn agriculture. For the four villages in Central Brazil which they studied, each of a different ethnic group, they found that the difficulty in extracting food from the environment led to a greater use of new techniques and tools for use in agriculture, hunting and fishing. In order to gain access to such tools, it became necessary for the communities to spend more time on the production of exchangeable goods. According to this explanation for levels of participation in regional economies, less emphasis is given on the effect of the superimposition of a dominant society's culture, and more emphasis is given on the alteration of environmental relationships. For example, reduction in game yields, and in some cases, arable land, is tied to a shrinking territory which accompanies the advance of Brazilian society. In such situations, the principal driving force towards greater economic relationships are the desire for trade goods which aid in subsistence activities, coupled with the loss of land for extensive lifestyles, requiring agricultural intensification and sale of agricultural products or wage labor on nearby farms or ranches.

In *Os Índios e a Civilização*, the anthropologist Darcy Ribeiro made predictions as to the eventual integration and assimilation of Indians into national society, based on the processes which were occurring at that time (Ribeiro, 1970). However, at a later date (Ribeiro, 1986), he noted that many of his predictions did not come true, as indigenous groups had displayed an unexpected resilience and tenacity for maintaining their ethnic identities. The specific predictions which Ribeiro made for the Ka'apor, in terms of their eventual integration, were questioned by Baleé (1989). Baleé states that the expected integration did not occur, and in fact, the Ka'apor resisted acculturation. This resistance was attributed to the fact that for the Ka'apor, the principal unit of production, consumption, and ritual life is the nuclear family. As such, they are less vulnerable to the breakdowns in social structure seen in more complexly structured indigenous societies, and which often accompany the transition to greater participation in market economies.

The situation of a number of indigenous groups in southern and northeastern Brazil is very near to Ribeiro's original concept of assimilation, yet, although they can be described as fully acculturated, they retain their identity as Indians. The explanation for this ethnic or cultural survival is given by Galvão (1979): these groups, having achieved a certain stability in their populations as well as in their relationships with surrounding society, have realized that to become integrated into this society implies entry at the lowest level of the social ladder, and so prefer to retain the identity of "Indians," a category which may allow a greater possibility of survival and perhaps even social recognition.

Community Development Projects

The federal agencies responsible for indigenous communities have a long history of promoting agricultural aid projects. Initially, with the S.P.I., the philosophy behind such activities was to "integrate" indigenous communities into Brazilian society, through organized agricultural production. For many years, such activities were officially viewed as extremely important for their "educational" aspect, i.e. integrating Indians into the market economy. This policy eventually gave rise to the "renda indigena" policy, in which communities were expected to provide income for FUNAI, through the sale of agricultural or forest products (Fisher, 1994). Although Brazilian national society's attempts to mold ethnic groups in the name of "integration" has most often been a means of disguising or excusing the theft of lands and/or natural resources, nevertheless, a significant quantity of resources have been spent on what have been called "community development projects."

Besides helping indigenous communities to organize trade in agricultural, forest, or craft products, as discussed earlier, FUNAI has also planned and subsidized a number of community development projects, with the goal of improving the livelihoods of indigenous communities. These projects involve a broad range of actions, from the introduction of new crop species or agricultural techniques, to more elaborate activities involving the purchasing of processing equipment, vehicles, and the commercialization of production. Besides FUNAI, other organizations, such as religious groups, NGOs, municipal governments and extension services, and the state-owned mining company CVRD, have also participated in community development projects for indigenous communities.

While an employee of the S.P.I., anthropologist Ribeiro (1962), admonished that the introduction of more complex agricultural technologies should be carefully studied, not only with regard to economic virtue, but also as to their compatibility with the lifestyle of the indigenous group. However, from information obtained from FUNAI employees, it appears that many agricultural projects were planned and executed strictly from an outsider's view of what was needed or important. According to an ex-member of FUNAI's advisory council (Conselho Indigenista), there are no specific guidelines within FUNAI for community development projects (J.P.F. Carvalho, pers. comm.). Most projects are demonstrations of the lack of understanding of how economic relations within a community are enmeshed in social systems. As a result, such projects often have ignored community traditions with respect to:

- division or organization of labor;
- calendar of agricultural, ritual, and subsistence activities;
- level of sharing or perception of what is community or individual property;
- adaptation of the traditional agricultural system to local environment and community needs.

Agricultural extension projects that entail the introduction of new agricultural crops or practices generally have as their goal the production of a marketable surplus.

While some of these efforts have met with success, perhaps a greater number have not accomplished their objectives, for a number of reasons. In many cases, projects often have not had a realistic view of community needs, and have also ignored the fact that many introduced crops (or animal husbandry activities) require a pre-existing level of expertise for their management or success. Despite Ribeiro's criticism of cattle as a panacea for economic problems of indigenous communities, for many FUNAI personnel, cattle-raising projects are an almost irresistible attraction (Ribeiro, 1962). To some extent, the problem of protein shortage, a result of shrinking territories and declining game populations, can be seen as a legitimate reason for seeking alternative supplies of protein. However, indigenous cultures are more "task" oriented, and the daily tending which livestock requires can be a difficulty. As Ribeiro (1962) observed among the Kadiweu of Mato Grosso do Sul, responsibility for caring for the cattle tends to fall on the shoulder of only a few individuals in the community. Previous experience with cattle may be an important determinant. In a survey of neo-Brazilian farmers living along the Transamazon Highway, it was found that involvement in cattle-raising was heavily dependent on an individual's prior experience, i.e. farmers with no history of cattle husbandry were unlikely to invest in this activity (Walker et al., 1997). Among the Waimiri-Atroari of Amazonas, a cattle project resulted in greatest responsibility for two individuals, who would often miss out on ritual festivals which took place in other villages (pers. obs.). Even flocks of chickens require care which poses a problem when an entire village wishes to travel.

Community development projects initiated by FUNAI have for the most part been carried out without an understanding of how market relationships will affect communities' social relations, ignoring that their traditional economies are enmeshed in kinship and social systems. As a result, forcing new economic relationships upon indigenous communities has often had deleterious effect on social cohesion and long-term sustainability, despite the fact that this is done with a view towards promoting improved livelihood.

In a study of a FUNAI-sponsored agricultural development project for the Bakairi of Mato Grosso, Picchi (1991) found that labor and social relations were affected in a number of ways. The mechanized rice production project, although viewed as a relatively benign assimilation program, nevertheless resulted in several negative impacts in the long term. These included the alteration of nutritional status due to the greater production of starchy foods, in detriment to the production of high quality protein; devaluation of the domestic unit of production; and the introduction of the concept of unequal access to the means of production.

Discussion

Although helping to improve the livelihoods of indigenous communities is certainly a worthy goal, community development projects that have sought to introduce or increase the production of some exchangeable commodity have had a number of drawbacks. Whether such projects can be blamed for the destruction of cultural values is open to debate - they may simply be the visible steps in a larger process of acculturation and establishment of economic linkages which accompanies the expansion of market-based economies. Even where projects may be able to explore a crop or product which is traditionally cultivated or gathered by the community, they may set up unequal economic relationships within that community. New definitions of "work" which alter social relations within a society, as discussed by Picchi (1991) can change levels of social cohesion and be a threat to long-term survival of the group. Social cohesion is of utmost importance to an indigenous community, in that it facilitates voicing concerns and pressuring FUNAI and local governments to take action concerning the community's needs. Such needs may include the maintenance of territorial integrity against invasion by loggers, squatters, and ranchers, or the access to personnel and material for health and education. The Kayapó, for example, have been able to affect policies that threaten their interests as a result of their ability to mobilize protests in order to pressure FUNAI and the federal government (Fisher, 1994).

The inefficacy of community development projects based on concepts of modernization is not restricted to examples involving indigenous groups in Brazil. The failure of development projects to achieve their goals of improving small farmers' livelihoods is in fact widespread and has increasingly been the subject of analysis (Bunch, 1995; Chambers, 1995). The recognition of such failures has led to challenges to the underlying concepts of development (Korten, 1990). There is a growing belief that if development is understood as the means by which positive and equitable ideals are concretely achieved, then such goals can only be achieved by involving communities directly in the definition of goals, planning, and execution of any aid activities (Black, 1991; Bunch, 1995). A number of methodologies which increase community participation in choosing development goals are now available (see for example Raintree, 1987; Muller and Scherr,1990 and Rocheleau, 1991). Given the poor record of FUNAI's community development projects, there is much room for improved methodologies for project design. Projects need to incorporate more realistic diagnoses of communities' needs, their degree of economic interaction with surrounding society, level of internal political organization, as well as agronomic capabilities, among other factors. A basic understanding is needed of the levels of decision-making (individual, household, kin group, village), and how this affects production and consumption. One aspect which is perhaps fundamental is the process through which outside goods (or money) make their way into a community and are redistributed within that community. Some of the questions to be asked are: Who spends cash obtained from exchanges or wage labor? For what? How does its distribution tie into kinship and social relations? How important is gender as a factor in subsistence and survival as communities move along a gradient of greater acculturation and relations to market economies? An understanding of these processes (and of the implications in changing them) would appear to be a basic prerequisite to any community development project.

Given the problems associated with the introduction of new crops, agricultural techniques and machinery, alternative efforts for community development should consider exploring the possibility of expanding on traditional agroforestry systems. Agroforestry systems are considered to have greater sustainability from a biophysical, socioeconomic and ecological point of view, especially for humid tropical regions, and should therefore have greater possibility of success in contributing to community self-sufficiency (Smith et al., 1996). Within the current scope of the science of agroforestry, consideration is given to diverse topics such as the incorporation of indigenous knowledge, gender issues, land and tree tenure, and other socioeconomic questions, all of which should be considered when planning projects for indigenous communities.

Conclusions

Changes in the economic systems of indigenous communities caused by outside intervention may result in internal social adjustments. Such adjustments may involve changes in the status of individuals and age or gender groups as well as in forms of natural resource use, and risk weakening social structures and community cohesion. If there is the need for generating some kind of aid for beleaguered communities, then it is essential that the members of the communities participate fully in the process. While it is useful to understand the external economic forces which impinge on indigenous communities, it is perhaps even more helpful to understand the overarching social structures which frame economic relations within such communities.

For indigenous communities entering or expanding a relationship with market economies, the focus of development aid should be activities which lead to community strengthening and well-being (such as health, education, food security, and reserve protection) and not necessarily revenue-generating activities. Decision-making as to the nature of aid activities should be returned to the community, to avoid tendencies of centralization and paternalism by FUNAI. Proponents of methodological frameworks which reject the modernization paradigm and its version of development offer a number of "Participatory tools" which can be explored for the design and implementation of community-strengthening projects. The largest problem or question which will remain, however, is how to turn this sensitive (or sensible) ideological framework into policy.

CHAPTER 3
AGROFORESTRY TRADITIONS IN THE BRAZILIAN AMAZON: FROM PREHISTORY TO THE PRESENT

This chapter will begin with a review of what is known about the origins of agroforestry in Amazonia, based on historical records and other sources, followed by a description of the traditional systems which exist in Amazonia, as well as those which have arisen in recent years. Current agroforestry systems can be grouped accordingly: (1) home gardens; (2) "agroforests" based on the açaí palm (*Euterpe oleracea* Mart.) in the Amazon estuarine region; (3) shaded plantation systems of commodity crops such as cacao (*Theobroma cacao* L.) and coffee (*Coffea arabica* L. and *C. canephora* Pierre ex A. Froehner); (4) mixed fruit and commodity systems, including those developed by Japanese immigrants and their descendants in Tomé-Açu, Pará, as well as those in widespread use in other parts of Amazonia; and other, less frequent forms of agroforestry, such as silvopastoral systems and living fenceposts.

Agroforestry in Amazonian Prehistory

Archeological evidence indicates that pre-ceramic foraging populations were living at various sites in Amazonia between 11,000 and 10,000 b.p. (before present). Initial occupation of the Pedra Pintada Cave near Monte Alegre, Pará, is estimated to be from 11,200 to 10,500 b.p., and excavations there have uncovered carbonized tree fruits, wood, and faunal remains, revealing a broad-spectrum economy of humid tropical forest and riverine foraging (Roosevelt et al., 1996). In other parts of the lowland neotropics (Colombia, Ecuador, Panama, and Peru), archeological and paleobotanical research indicate that there was an intensification of practices surrounding plant exploitation and human interference with the environment between 10,000 and 8,600 b.p. These practices resulted in forms of horticulture emphasizing both native tubers and seed plants, and probably also involved the deliberate planting or management of trees. By 7000 b.p. larger scale food production had emerged, with the cultivation of substantial areas, or fields, away from houses (Piperno and Pearsall,1998). In a site in Rondônia, where human occupation by hunter-gatherers dates to 9000 yrs. b.p., vestiges of agriculture begin to appear around 4500 yrs. b.p. (Miller, 1992).

At some time in the past, native fruit trees went through a process of domestication and were incorporated into prehistoric agricultural systems. It is likely that this was through the "dump heap" or incidental route to domestication, where seeds of edible fruits collected in the forest were discarded near dwellings, as was the case at Pedra Pintada Cave. While Lathrap (1977) believed the house garden of fruit trees and other useful plants to be the locus of agricultural experimentation, with root and tuber crops initially introduced as minor additions to the food supply, Piperno and Pearsall (1998) believe that the primary focus of early agricultural systems in the neotropics was on carbohydrate-rich root or tuber crops, with trees as secondary components. Despite methodological advances in archeology, such as the ability to botanically identify the sources of starch grains on stone artifacts (Piperno et al., 2000), we will probably never know exactly in which sequence plants were domesticated in the neotropics. It is likely, though, that the domestication of trees went hand-in-hand with root crop domestication, as the maintenance of gardens around dwellings would have provided an ideal location for the establishment of useful tree species and eventually their domestication.

The early horticulturalists initially left sites of modest size, indicating small but stable settlements. However, by 3000-2000 b.p. larger villages of many hectares existed on the middle and lower Orinoco River in Venezuela. By 2000 years ago, large, socially stratified chiefdoms exhibiting elaborate ceremonial art and well-established trading networks were thriving along the principal rivers of Amazonia (Roosevelt, 1994). These societies were described by the Jesuit friar Gaspar de Carvajal in the first account of exploration of the Amazon. Carvajal accompanied Francisco Orellana's expedition, setting out from the Napo River in Peru and traveling down the Amazon in 1541-2. These first Europeans to travel the Amazon encountered villages of very large size, with substantial stores of food, namely manioc bread, maize, dried fish and penned turtles (Carvajal, 1970). The Jesuit priest Cristobal de Acuña descended the Amazon in 1639, and described a similar scenario. He found the province of the Omagua nation extending for more than 200 leagues (1 league = 4.5-5.0 km), with many villages, and one village of the Yorimane nation extending for more than one league along the riverbank (Acuña, 1994). Based on various historical sources and remote sensing imagery, Porro (1996) estimated the Omagua population to be around 18,000 persons at that time. In less than 100 years after Acuña's report, however, the great chiefdoms along the Amazon had succumbed to epidemics of imported diseases, enslavement and missionization. Father João Daniel, writing in 1757-76, described large stretches of the main river and its tributaries as being totally deserted (Daniel, 1976).

An examination of the historical accounts that record the impressions of the first Europeans to travel the Amazon does not provide much information on the nature and origin of the indigenous agroforestry systems which existed at that time. Carvajal, for example, mentions only that "much fruit of all kinds" was found in one village, and that the road leading to another village was planted to fruit trees on one side and the other (Carvajal, 1970). Acuña records that along with the staple crops of manioc (*Manihot esculenta* Crantz), sweet potatoes (*Ipomea batata* [L.] Lam.), yams (*Dioscorea trifida* L.f.), and others, the Indians cultivated "bananas,"[4] pineapple (*Ananas comosus* [L.] Merr.), guava (*Psidium guajava* L.), abiu (*Pouteria caimito* [Ruiz & Pav.] Radlk.), and Brazil nut (*Bertholletia excelsa* Humb. & Bonpl.). He praised their plantations of cotton (*Gossypium barbadense* L.) and tobacco (*Nicotiana tabacum* L.), with an eye to their potential for commerce, and the numerous medicinal plants which were in use (Acuña, 1994).

Although the great chiefdoms of Amazonia had ceased to exist once the Portuguese became firmly established, accounts by the chroniclers of the colonial period offer more detail and can give us an idea of what pre-Columbian agriculture may have been like. Father João Daniel's two volume tome, written between 1757 and 1776, and based on his 17 years in Amazonia, describes in detail indigenous methods of slash-and-burn agriculture with stone axes, and mentions some of the fruit trees cultivated. The abiu, for example, was described as one of the most cultivated fruits in Amazonas. The custard apple (*Annona squamosa* L.) and the biribá (*Rollinia mucosa* [Jacq.] Baill.) are listed as dooryard fruits ("fructos hortenses"), and the cashew (*Anacardium occidentale* L.) as the fruit most cultivated by both "wild" and "tame" Indians, with several varieties, distinguished by color, size, and acidity. The cashew was also said to grow in great abundance in sandy areas, beaches, and river banks. Two types of genipap (*Genipa americana* L.) were distinguished, a large-fruited cultivated variety, and a smaller wild one. The guava was described as cultivated, but also growing spontaneously in savannas and open areas. Papaya (*Carica papaya* L.) was described as growing anywhere, without any special care. Indians grew passion fruit (*Passiflora edulis* Sims) on trellises in their fields. Some other species, such as the various *Inga*, pitomba (*Talisia esculenta*), and the ginja (identity unknown), are also mentioned, although no details are given about their cultivation. Nevertheless, it is probable that these were also cultivated, as other fruits such as the mangaba (*Hancornia speciosa* Gomes), the copu-miri [cupuí](*Theobroma subincanum* Mart.) and sorva (*Couma utilis* [Mart.] M. Arg.) are specifically described as wild fruits (Daniel, 1976).

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[4] These are unlikely to be true bananas (*Musa* sp.)

The Brazilian naturalist Alexandre Rodrigues Ferreira, employed by the Portuguese crown to scientifically explore the Amazon from 1783-1792, described peach palm (*Bactris gasipaes* H.B.K.) as being highly appreciated, and one of the first trees to be planted by farmers in front of their houses and in their fields. Indians planted them around their villages, and for river travelers, the tall palms seen from afar were a sure sign that human habitation was near (Ferreira, 1972).

Although we will never know the extent to which trees were cultivated by pre-Columbian societies in Amazonia, it appears that many forest fruits had been domesticated by the time of the European conquest, and it is possible that many more species were in a state of semi-domestication. A number of commonly cultivated Amazonian fruit trees have the characteristics of long periods of selection and genetic improvement. Clement (1989) suggests a center of crop diversity in Western Amazonia, based on the genetic diversity of fruit tree domesticates, such as abiu, South American sapote (*Quararibea cordata* [Humb. & Bonpl.] Vischer), peach palm, biribá, mapatí (*Pourouma cecropiaefolia* Mart.), and araçá-boi (*Eugenia stipitata* McVaugh). The domestication and genetic improvement of native fruit trees also occurred in other locations around Amazonia. Clement (1989) cites the muricí (*Byrsonima crassifolia* L. Kunth), from the region of Santarém, and guaraná (*Paullinia cupana* H.B.K. var. *sorbilis*) from the Maués region. Large pajurá fruits (*Couepia bracteosa* Bth.), sold in the Manaus market, much larger than those produced by wild forest trees, also come from the Santarém region (Ducke, 1946 and pers. obs.). Inhabitants of Alter-do-Chão, a region of savanna near Santarém, are reported to cultivate a number of cashew varieties, each with a specific use (I.S. Miranda, pers. com, 1989).

With the lack of solid historical accounts about agroforestry practices in Amazonia at the time of European contact, perhaps the next best possible source of information is to be found in the agricultural practices of modern day indigenous peoples. This approach will be discussed in the following section.

Traditional Indigenous Agroforestry Systems

In light of the historical and archeological evidence for the existence of complex and stratified societies in Amazonia, Roosevelt et al. (1996) have questioned the use of the lifestyles of modern day indigenous groups as a model for either Paleolithic adaptations or for a pre-Columbian scenario. A more likely model is that modern tribal groups represent the populational and cultural fragments which survived and in many cases, regrouped, following the colonial decimation. Despite the upheavals caused by colonization, agricultural systems relying on a number of the domesticated plants also survived. Whether or not the specific cultivation methods employed by contemporary indigenous groups are the same as those of their ancestors is a more difficult question to answer. However, it is likely that the agroforestry systems used by indigenous peoples today contain many of the elements of systems which were in existence prior to European influences. Some examples of these indigenous agroforestry systems, as described in the ethnobiological literature of the past few decades, are listed in Table 3-1. They range from the cultivation of fruit trees and other useful plants around dwellings, to the incorporation of trees in agricultural fields and fallows, and involve the following practices:

- Useful tree species are spared when forest is felled for agriculture;
- Seedlings of useful forest species that regenerate in agricultural plots are spared during weeding;

- Fruit trees growing in old fallows are spared when these areas are again cleared for agriculture;
- Seeds of fruit trees are interplanted with staple crops;
- Seedlings are grown in house gardens for transplanting to fields;
- Seeds are dispersed haphazardly around houses and allowed to grow;
- Fruit trees and other useful plants are actively planted and managed around houses;
- Seeds of fruit trees are planted along trails in old swiddens or in forest clearings.

These various practices may result in several configurations of fruit tree establishment:

- the "home garden", an assemblage of fruit trees and other useful plants such as condiments and medicinals, grown in close proximity to the house;
- a belt of fruit trees surrounding a village;
- fruit trees interspersed with field crops;
- orchards of mixed fruit trees; and
- fallows of forest species enriched with fruit trees.

These systems often represent a fine tuning of knowledge about plants and the environment, as well as interactions with agricultural and social systems, and it is likely that they represent technologies that evolved along with the domestication of the forest species and their use in agricultural systems.

The Colonial Period

With the establishment of the Portuguese in Eastern Amazonia, a number of exotic species were introduced and incorporated into indigenous agroforestry systems. The Portuguese crown officially sponsored a number of plant introductions from its

TABLE 3-1: Examples of fruit tree cultivation by indigenous communities in Amazonia*

ETHNIC GROUP	PRACTICES
Amuesha [eastern Peru]	Old fruit trees are left in fields cleared from fallows. Cacao is planted under plantains, then underplanted with ice-cream bean. Yard gardens had up to 26 species providing an edible product (excluding herbs, medicinals, etc.); families with more diverse yard gardens had less diverse agricultural fields (Salick and Lundberg, 1990).
Andoke & Witoto [southeast Colombia]	Papaya is planted between buttresses of tree stumps or in locations with abundance of ash. Other fruit trees are interplanted with initial manioc crop, w/ an average density of 363 trees/ha, and reach greatest production 5-10 yrs after initial field establishment. Yard gardens next to houses include most of the tree species found in fields, along with condiments and other useful plants (Eden and Andrade, 1987).
Bará [Colombia/ Brazil]	Men plant fruit trees, both in fields and close to the longhouse. Species include peach palm, mango, papaya, lime, caimito, uvilla, ice-cream bean. Other cultivated species include coca, calabash tree, yagé and tobacco (Jackson, 1983).
Bari [eastern Peru]	Banana plants composing outer ring of agricultural field may be interplanted with avocado and annato (Beckerman, 1983).
Bora [eastern Peru]	Agricultural plots include 10 or more species of fruit trees, as well as coca and barbasco. Fruit trees are planted as seeds or seedlings amid manioc plants. In the initial clearing of the forest, important fruit and other trees (e.g. West Indian cedar) tend to be protected. During weeding, seedlings of useful trees are often spared (Denevan, et al., 1984; Padoch and de Jong, 1987).
Campa [eastern Peru]	Tree and shrub crops are inserted well after initial planting of the field. Some fruit trees germinate from seeds discarded after fruit are eaten near the houses (Denevan, 1971).
Candoshi [eastern Peru]	Papaya is planted in the fields. Medicinal plants and condiments are grown adjacent to houses in a bare-earth zone (Stocks, 1983).
Cocama [western Amazon, Brazil]	When secondary forests (fallows) are felled and burned for agriculture, individual Brazilnut trees are protected from fire damage by a encircling ring of uncut vegetation (Pereira, 1992).
Cocamilla [eastern Peru]	Dooryard gardens emphasize plantains and bananas as well as condiments and medicinals (Stocks, 1983).

* Scientific names are given in Table 3-2

TABLE 3-1: Examples of fruit tree cultivation by indigenous communities in Amazonia

Desana [Colombia/ Brazil]	Peach palm, avocado, papaya and custard apple are found near the communal dwelling in a semi-cultivated state. Cotton, tobacco and barbasco are also cultivated (Reichel-Dolmatoff, 1971).
Jivaro (Huambisa & Aguaruna) [eastern Peru]	Fruit trees such as peach palm, papaya and others are cultivated along with staple crops in fields (Boster, 1983).
Kayapó [eastern Amazon, Brazil]	Papaya is planted near or in the middle of groups of banana plants, and may be grown in a nursery next to the house and transplanted when 40-100 cm high. Brazil nuts are planted in forest clearings. Several species of fruit trees are planted along trails in old swiddens. Ashes, termite and ant nests, and spoiled fish flour are used as fertilizer (Kerr and Posey, 1984; Posey, 1985).
Ka'apor [eastern Amazon, Brazil]	After houses are established in a new swidden plot, the area around the houses is planted to a number of fruit trees and useful plants (a total of 66 species). Some species are planted in old swiddens: inga, wild cacao, hog plum and velvet tamarind (Baleé, 1993).
Machiguenga [southeast Peru]	70 species of plants are cultivated in house gardens for teas, relishes, medications and crafts (Johnson and Behrens, 1982).
Siona-Secoya [Ecuador]	Peach palm seedlings are grown in house gardens for transplanting to fields. House gardens are ⅓ to ½ ha. in size, and make up 35-40% of total cultivated land (Vickers, 1983).
Waimiri-Atroari [northern Amazon, Brazil]	Seeds of fruit trees are planted in new swidden plots surounding the communal house, often besides stumps, or in the case of peach palm and papaya, where there is abundant ash. Some species are spontaneous from seeds in domestic trash discarded in the swidden. Over time, a belt of fruit trees is established around the village (Miller, 1994).
Yanoama (Barafiri) [Venezuela]	Peach palm is intercropped with plantains. Papaya is spontaneous on trash heaps near dwellings (Smole, 1976).
Yanomamo (Waika) [Venezuela]	Papaya and banana form a discontinuous canopy underplanted with cocoyam and many other herbaceous crops. Peach palms, plantains and cotton are usually the only crops surviving in gardens after the 4th year (Hames, 1983).

* Scientific names are given in Table 3-2

TABLE 3-2: Scientific names of plants cited in Table 3-1*

COMMON NAME	SCIENTIFIC NAME	FAMILY
Annato	*Bixa orellana* L.	Bixaceae
Avocado	*Persea americana* Mill.	Lauraceae
Banana	*Musa* sp.	Musaceae
Brazil nut	*Bertholletia excelsa* Humb.& Bonpl.	Lecythidaceae
Cacao	*Theobroma cacao* L.	Sterculiaceae
Caimito	*Pouteria caimito* (Ruiz & Pav.) Radlk.	Sapotaceae
Calabash tree	*Crescentia cujete* L.	Bignoniaceae
Cashew	*Anacardium occidentale* L.	Anacardiaceae
Coca	*Erythroxylum coca* Lam.	Erythroxylaceae
Coconut	*Cocos nucifera* L.	Arecaceae
Cocoyam	*Xanthosoma sp.*	Araceae
Cotton	*Gossypium sp.*	Malvaceae
Cupuaçu	*Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum.	Sterculiaceae
Guava	*Psidium guajava* L.	Myrtaceae
Hog plum	*Spondias mombin* L.	Anacardiaceae
Ice-cream bean	*Inga edulis* Mart.	Mimosaceae
Lime	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae
Mango	*Mangifera indica* L.	Anacardiaceae
Mountain soursop	*Annona montana* Macfad.	Annonaceae
Orange	*Citrus sinensis* (L.) Osbeck	Rutaceae
Papaya	*Carica papaya* L.	Caricaceae
peach palm	*Bactris gasipaes* Kunth	Arecaceae
plantain	*Musa x paradisiaca* L.	Musaceae
rose apple	*Syzygium jambos* (L.) Alston	Myrtaceae
tobacco	*Nicotiana tabacum* L.	Solanaceae
uvilla	*Pourouma cecropiifolia* Mart.	Moraceae
velvet tamarind	*Dialium guianensis* Steud.	Caesalpiniaceae
West Indian cedar	*Cedrela odorata* L.	Meliaceae
wild cacao	*Theobroma speciosum* Willd. Ex Spreng.	Sterculiaceae
wild sweetsop	*Rollinia mucosa* (Jacq.) Baill.	Annonaceae
yagé	*Banisteriopsis caapi* (Spruce ex Griseb.)	Malpighiaceae

* When possible, nomenclature was consolidated according to Rehm (1994).

Eastern colonies of Goa and Macau (Dean, 1995). Mango (*Mangifera indica* L.) and jackfruit (*Artocarpus heterophyllus* Lam.) are mentioned in Father João Daniel's tome on Amazonia (written in 1757-76), however, in the case of mango, more in a tone of lament that it was not cultivated as widely as in other parts of Brazil (Daniel, 1976). The efforts on the part of the Portuguese to introduce useful plants included the establishment of a botanical garden in Belém, which benefitted from the skills of two Frenchmen who fled the unrest in French Guiana following the French Revolution. In 1808, the Portuguese invaded French Guiana and were able to take advantage of the collection of useful plants cultivated at "La Gabrielle," the botanical garden in Cayenne. After the Portuguese takeover, Maciel da Costa, appointed as civil administrator, further developed and enriched "La Gabrielle," and by the time Cayenne was returned to the French in 1818, he had remitted to Belém a number of tropical species including nutmeg (*Myristica fragrans* Houtt.), carambola (*Averrhoa carambola* L.), groselha (?), sapodilla (*Manilkara zapota*), breadfruit (*Artocarpus altilis* [Parkinson] Fosberg), sugarcane (*Saccharum officinarum* L.), as well as European fruit trees (unspecified) which had been acclimated in Cayenne (Holanda, 1965). Until today, some plants cultivated in Brazil retain the epithet "*caiano*" to describe their Cayennese origin. Examples are varieties of sugar cane, a variety of papaya, and the bilimbi (*Averrhoa bilimbi* L.), called *limão caiano*.

By the mid 19th century, exotic fruit trees were fully incorporated into home gardens along the Amazon. Traveling on the Amazon between Óbidos and Manaus in 1849, the naturalist Henry Walter Bates described home gardens with fruits such as banana, papaya and mango, orange (*Citrus sinensis* [L.] Osbeck), lemon (probably *C.*

aurantiifolia [Christm.] Swingle), guava, avocado (*Persea americana* Mill.), abiu, genipap, banana, and biribá, as well as coffee trees growing under the shade of the fruit trees (Bates, 1988). Ten years later, French traveler Avé-Lallemant recorded a number of fruit trees growing near houses on the outskirts of Belém in 1859: banana, mango, jackfruit, various Annonaceae, orange trees, coffee, as well as giant granadilla or maracujá-açu (*Passiflora quadrangularis* L.). Surrounding the dwellings of Indians near Cametá, Pará, he found calabash trees (*Crescentia cujete* L.), orange trees competing with mango, açaí and bacaba (*Oenocarpus bacaba* Mart.) palms. Income sources for these households came from "extensive stands of cacau" and rubber trees. The presence of various Annonaceae, the "pacuri" (most likely the bacuri, *Platonia insignis* Mart.) and Brazil nut trees were also noted. Continuing up the Amazon to Santarém, he found many cacao and orange groves, as well as concentrations of the tucumã palm (*Astrocaryum aculeatum* Meyer), which is highly appreciated for the edible mesocarp of its fruit (Avé-Lallemant, 1980).

Some of the home garden systems established in the 19th century may still be in existence today. Near Manaus, in the municipality of Manacapuru, a stretch of the left bank of the Solimões River receives the name of "Costa do Laranjal" as it was a region which traditionally supplied Manaus with oranges. This high river bank, far above any flood level, has an extensive anthropogenic black earth site, and home gardens with very large Brazil nut, rubber (*Hevea brasiliensis* [Willd. ex A. Juss.] Müll. Arg.), and cupuaçu (*Theobroma grandiflorum* [Willd. ex Spreng.] K. Schum) trees, thought to be over 100 years old (J.B.G. Moreira, pers. com., 1999).

The rapid spread of introduced species of fruit trees in the 18th and 19th century shows a willingness to experiment with new and interesting germplasm, indicating that there was probably a definite "home garden culture" among the population of Amazonia, who at the time were "caboclos" of predominantly of Indian descent. That this culture was not appreciated by European observers may be due to their cultural prejudices, or perhaps to the haphazard appearance of home gardens, which can obscure the often complex levels of management. Bates (1988), for example, duly noted the presence of fruit trees around houses, but then expressed his wish to see the natives "plant orchards of the choicest fruit trees around their houses." From the farmer's point of view, however, if there was no way to market the products, then there would have been little incentive to plant more fruit than necessary for domestic consumption. Such economic questions, along with others, will be considered in more detail in the following section on home gardens.

Home Gardens

The home garden, an assemblage of useful trees, shrubs, and herbs cultivated in the proximity of houses, appears to be ubiquitous in tropical regions around the world. It comes as no surprise, therefore, that home gardens are the most widespread form of agroforestry system in the Amazon region. Besides historical references, a number of modern studies have described home garden systems in both *várzea* (flood plain) and *terra firme* (unflooded) regions of Amazonia. These are summarized in Table 3-3. Present day home gardens of both small-scale farmers as well as urban populations in

Amazonia combine native species with those which have been introduced from other parts of the globe during European colonization, as well as more recent introductions. A list of the species found in present day home gardens and their uses is given in Table 3-4. This list is based on the literature, and species were only included if they were cited by two or more sources.

Home gardens receive two key benefits from their location around houses. The first is the possibility of greater nutrient inputs around dwellings, in the form of domestic wastes and human and animal feces and urine. The second is the greater propensity of farmers to weed around and protect useful plants when these grow nearby their houses. These may or may not be intentionally planted. A very important process in the establishment and expansion of home gardens is the recruitment of volunteer plants which arise from discarded seeds, as was described in the section on traditional indigenous systems. Useful plants arising in this way will commonly be spared during periodic weeding around houses. This is certainly a cost-effective way of establishing fruit trees, or expanding a garden out from its original core or nucleus immediately adjacent to the dwelling. In many instances, such trees will eventually become features of the *terreiro*, or bare earth yard.

The importance of home gardens appears to be chiefly the domestic supply of fruits, medicinals, craft products, and shade. Near urban centers, however, they may become more important in producing marketable fruit. Despite the importance given to markets in the construction of theories in cultural geography and economic anthropology, little quantitative research has been done on how the proximity to urban centers affects agroforestry systems, in terms of the relative importance to farmers' income or species choice. Some recent studies, however, have begun to look at the economic importance of home gardens in household livelihood systems in Amazonia. Studies by Rosa et al. (1998b, 1998c) in Pará and Macapá found that small livestock can have considerable economic importance as components of the homegarden system. Their survey of 32 properties in the region of Macapá, capital of Amapá, found average property sizes of 90 ha, with a mix of forest and subsistence agriculture, and home gardens averaging 0.32 ha. While more than 50% of the chickens, ducks, and pigs raised on these properties are consumed by the household, weekly revenue from livestock averaged R$ 35,[5] which was greater than the revenues from the sale of fruits such as açaí, bananas, mangos, limes, and cupuaçu, which averaged R$ 20/week. A good portion of the feed for these animals was said to come from home garden fruit. In a sample of 20 households in Murinin, near Belém, capital of Pará, the average property size was found to be 1.7 ha, with home gardens occupying 0.64 ha. In terms of the frequency of fruit trees, 100% of the properties had açaí and cupuaçu, 90% had guava and lime, 85% had peach palm and mango, 80% had coconut, 75% had banana, and 70% had biribá and jackfruit. Family consumption accounted for 69% of the fruit, 100% of the medicinals, 85% of the vegetables, and 85% of the livestock.

For those living near cities, home gardens can be part of both subsistence and income-earning strategies. Little is known, however, about the choices farmers make, in terms of the composition and management of their home gardens, that could influence production and income in one way or another. It is possible that there is a stock of species which are ubiquitous and valued for domestic consumption, while others are cultivated specifically as income-earners. Many studies of home gardens provide lists of species, yet very few information about the ranking of these species with regard to their relative economic importance. Likewise, little is known about any special care or management which the more important species may be receiving.

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[5] The real (R$) was approximately equal to the dollar at that time

Some studies have shown that the composition of home gardens may be strongly influenced by a farmer's place of origin. In the state of Acre, for example, Nobre (1998) found that home gardens belonging to rubber tappers were generally less diverse than the home gardens of colonists who had arrived from other regions. Although this would appear contradictory, the explanation is that the rubber tappers have a much greater knowledge of the forest, and make greater use of its non-timber products for their domestic needs, whether as medicines or foods. Settlers from other regions have less knowledge of the forest, and tend to rely more on cultivated plants for their needs.

In the cases described above, the preponderant use of home gardens is for domestic consumption, indicating that from the point of view of food security, home gardens can be a valuable technology for small scale farmers, regardless of their distance to markets. Home gardens may be of special value to farmers in frontier regions, where conditions for survival are more problematic.

Table 3-3: Research on home gardens in the Brazilian Amazon

Author(s)	**Location(s)**[1]	**Ecosystem(s)**[2]	**Comments**
Bentes-Gama et al. (1999)	Bragança, PA	Terra firme	In four home gardens studied, the most important trees were coconut, guava, açaí, and mango. The lower strata were dominated by bananas, coffee, cotton, muriçí, and lime.
Guillaumet et al. (1993)	Careiro Island, AM	Várzea	Houses are situated on the highest levees of the river bank, generally on sites once occupied by old rubber and cacao plantations. Home gardens are composed of indigenous and exotic fruit trees and other useful species, as well as rubber. The home garden merges into a belt of banana and more flood resistant trees (guava, açaí, genipap, ingá) on the back slope of the levee. A list of species is provided.
INPA (1988)	3 colonization projects (Juma, Rio Preto da Eva, Bela Vista), AM	Terra firme	In the older settlements of R.P. da Eva and Bela Vista, where settlers are of Amazonian origin, approximately 75% of the farms had home gardens. Only 40% of farms had home gardens in Juma, where settlers are from other parts of Brazil, however, the total number of species was greater, and included more species recently introduced to the region. Avocado, mango and citrus were among the most common species in all three locations. Although cupuaçu was the most frequent species in R.P. da Eva and Bela Vista, it was practically unknown in Juma. Seedlings are often prepared by women. Management of home gardens is minimal, limited to weeding (yearly or twice yearly) and occasional use of manioc peelings as fertilizer.

1. States are abbreviated as follows: AC-Acre; AM-Amazonas; AP-Amapá; PA-Pará; RO-Rondônia.
2. Várzea-floodplain; Terra firme-unflooded lands

Table 3-3: Research on home gardens in the Brazilian Amazon

Author(s)	**Location(s)**[1]	**Ecosystem(s)**[2]	**Comments**
Rosa et al. (1998a)	Amazon estuary, PA	Várzea	Description
Rosa et al. (1998b)	Amazon estuary, AP	Várzea ?	A survey of 32 properties in the region of Macapá, capital of Amapá, found average property sizes of 90 ha, with a mix of forest and subsistence agriculture, and home gardens averaging 0,32 ha. While more than 50% of the chickens, ducks, and pigs raised on these properties are consumed by the household, weekly revenue from livestock averaged R$ 35, which was greater than the revenues from the sale of fruits such as açaí, bananas, mangos, limes, and cupuaçu, which averaged R$ 20. A good portion of the feed for these animals was said to come from home garden fruit.
Rosa et al. (1998c)	Murinim-Benfica Benevides, PA	Terra firme	In a sample of 20 households the average property size was found to be 1,7 ha, with homegardens occupying 0.64 ha. In terms of the frequency of fruit trees, 100% of the properties had açaí and cupuaçu, 90% had guava and lime, 85% had peach palm and mango, 80% had coconut, 75% had banana, and 70% had biribá and jackfruit. Family consumption accounted for 69% of the fruit, 100% of the medicinals, 85% of the vegetables, and 85% of the livestock.
Santos et al. (1998)	Terra Nova, Itapiranga, AM	Terra firme	Description of a home garden.

1. States are abbreviated as follows: AC-Acre; AM-Amazonas; AP-Amapá; PA-Pará; RO-Rondônia.
2. Várzea-floodplain; Terra firme-unflooded lands

Table 3-3: Research on home gardens in the Brazilian Amazon

Author(s)	**Location(s)**[1]	**Ecosystem(s)**[2]	**Comments**
Siviero (1994)	Negro and Solimões Rivers, excluding Manaus greenbelt (AM)	Terra firme	55 properties on the Negro and 46 on the Solimões were visited. 100% of the farms had home gardens, ranging in size from 0.5 to 4.0 ha. Management of home gardens, once they are established, is minimal. Use of manioc peelings for fertilizer was observed on some properties. Surplus products are sold in nearby towns, or to river traders, or given to neighbors and relatives. A list of the 37 most frequently cultivated species is given.
Smith (1996b)	Pioneer roads in rural PA; floodplain of middle Amazon	Terra firme, várzea	77 species (excluding ornamentals and medicinal plants) were found in 33 home gardens on terra firme. 80 species were found in the 18 home gardens sampled on the floodplain. About 1/3 of the species are found in both environments, but there was no significant difference in overall species diversity. Home gardens could be a source of new germplasm for agroforestry and perennial cropping systems.
Sousa & Sousa (1999)	Municipalities of Manaus and Presidente Figueiredo, AM	Terra firme	41 home gardens were surveyed in two communities, and a total of 38 species were identified. Cupuaçu was the most frequently planted fruit tree. Other important perennials were: avocado, citrus, coconut, ingá, jackfruit, mango, and peach palm.

1. States are abbreviated as follows: AC-Acre; AM-Amazonas; AP-Amapá; PA-Pará; RO-Rondônia.
2. Várzea-floodplain; Terra firme-unflooded lands

Table 3-3: Research on home gardens in the Brazilian Amazon

Author(s)	**Location(s)[1]**	**Ecosystem(s)[2]**	**Comments**
Yamada (1998)	Tomé-açu, PA (colony of Japanese-Brazilian farmers)	Terra firme	Home gardens are maintained by almost every farmer, and range in size from 1-3 ha. Home garden areas may also include seedling nurseries, hen houses, pigsties, tortoise pens or small fish ponds. Boundaries may be difficult to distinguish, as home gardens may merge into orchards of perennials. Most new species are introduced by men, who travel more, but some women have made collections of medicinal plants. Products are consumed domestically, given away, or sold in local markets. New species are tested in home gardens prior to more extensive planting in fields

1. States are abbreviated as follows: AC-Acre; AM-Amazonas; AP-Amapá; PA-Pará; RO-Rondônia.
2. Várzea-floodplain; Terra firme-unflooded lands

Table 3-4: Perennial species frequently found in home gardens in the Brazilian Amazon

FAMILY/SPECIES[1]	COMMON NAME (English/Portuguese)	MAIN USE
Anacardiaceae		
Anacardium occidentale	Cashew/Caju	Fruit, nut
Mangifera indica	Mango/Manga	Fruit
Spondias dulcis	Golden apple/Cajá-manga	Fruit
Spondias mombin	Hogplum/Taperebá,Cajá	Fruit
Annonaceae		
Annona muricata	Soursop/Graviola	Fruit
Annona squamosa	Custard apple/Ata, Pinha	Fruit
Rollinia mucosa	Wild sweetsop/Biribá	Fruit
Arecaceae		
Astrocaryum aculeatum	Tucum palm/Tucumã	Fruit
Bactris gasipaes	Peach palm/Pupunha	Fruit
Cocos nucifera	Coconut/Coco	Kernel
Euterpe oleracea	Assai palm/Açaí	Fruit
Oenocarpus bacaba	Bacaba palm/Bacaba	Fruit
Bignoniaceae		
Arrabidea chica	?/Crajiru	Leaves (medicine)
Crescentia cujete	Calabash tree/Cuieira	Husk (utensil)
Bixaceae		
Bixa orellana	Annatto/Urucum	Seed (colorant)
Bromeliaceae		
Ananas comosus	Pineapple/Abacaxí	Fruit
Caricaceae		
Carica papaya	Papaya/Mamão	Fruit
Euphorbiaceae		
Hevea brasiliensis	Rubber/Seringa	Latex
Icacinaceae		
Poraqueiba sericea	/Umari	Fruit
Lauraceae		
Persea americana	Avocado/Abacate	Fruit

Table 3-4: Perennial species frequently found in home gardens in the Brazilian Amazon

FAMILY/SPECIES[1]	COMMON NAME (English/Portuguese)	MAIN USE
Lecythidaceae		
Bertholletia excelsa	Brazil nut/Castanha do Pará	nut, bark (medicinal)
Leguminosae-Caesalpinioidae		
Tamarindus indica	Tamarind/Tamarindo	Fruit
Leguminosae-Mimosoidae		
Inga edulis		
Inga	Ice cream bean/Ingá-cipó	Fruit
		Fruit
Malpighiaceae		
Byrsonima crassifolia	Nance/Muricí, Muruçí	Fruit
Malpighia emarginata	Barbados cherry/Acerola	Fruit
Malvaceae		
Gossypium sp.	Tree cotton/Algodão	Fiber
Meliaceae		
Cedrela odorata	Spanish Cedar/Cedro	Timber
Moraceae		
Artocarpus altilis	Bread fruit/Fruta-pão	Fruit, seeds
Artocarpus heterophyllus	Jack fruit/Jaca	Fruit
Morus nigra	Mulberry/Amora	Fruit
Pourouma cecropiifolia	/Mapatí	Fruit
Musaceae		
Musa sp.	Banana/Banana	Fruit
Myrtaceae		
Eugenia stipitata	?/Araçá-boi	Fruit
Eugenia uniflora	Surinam cherry/Pitanga	Fruit
Psidium guajava	Guava/Goiaba	Fruit
Syzygium cumini	Jambolan/Azeitona	Fruit
Syzygium jambos	Rose apple/Jambo Rosa	Fruit
Oxalidaceae		
Averrhoa carambola	Star fruit/Carambola	Fruit

Table 3-4: Perennial species frequently found in home gardens in the Brazilian Amazon

FAMILY/SPECIES[1]	COMMON NAME (English/Portuguese)	MAIN USE
Passifloraceae		
Passiflora edulis	Passion fruit/Maracujá	Fruit
Piperaceae		
Piper nigrum	Black pepper/Pimenta-do-reino	Seed (condiment)
Rubiaceae		
Coffea arabica	Coffee/Café	Seed
Genipa americana	Genipap/Jenipapo	Fruit
Rutaceae		
Citrus aurantifolia	Lime/Limão	Fruit
Citrus reticulata	Tangerine/Tangerina	Fruit
Citrus sinensis	Sweet orange/Laranja	Fruit
Sapindaceae		
Paullinia cupana	Guarana/Guaraná	Seed
Talisia esculenta	?/Pitomba	Fruit
Sapotaceae		
Pouteria caimito	Caimito/Abiu	Fruit
Sterculiaceae		
Theobroma cacao	Cacao/Cacau	Fruit, seed
Theobroma grandiflorum	/Cupuaçu	Fruit

1. Nomenclature was consolidated according to Wiersema & León (1999)

Açaí-based Systems in the Amazon Estuary Region

The use of the açaí palm (*Euterpe oleracea*) in the estuarine region at the mouth of the Amazon is a tradition of great antiquity. Archeological excavations on Marajó Island in the Amazon estuary have found a great abundance of açaí seeds among carbonized plant remains at a site where occupation has been dated to AD 1100-1300 (Roosevelt, 1991). Although the stratified societies or chiefdoms which existed along the Amazon and on Marajó Island disappeared in the early colonial period, it is likely that some of their subsistence practices lived on and were perpetuated by the population of mixed blood which eventually replaced them. In 1859, for example, French traveler Avé-Lallemant found açaí to be a staple food in the diet of the populace of Belém (Avé-Lallemant, 1980).

Agroforestry systems based on the açaí palm have received a great deal of interest on the part of researchers in recent years (Anderson, 1988; Strudwick and Sobel, 1988). These systems are chiefly concentrated around the city of Belém, on islands in the Amazon estuary and in the nearby municipality of Cametá, at the mouth of the Tocantins River. According to IBGE (1998), Cametá produced 78% of Pará's açaí in 1995, and Pará itself was responsible for 94% of Brazil's açaí production, followed by Maranhão and Amapá. Total fruit production in 1995 was estimated at 108,922 metric tons, with a value of R$ 35,075,000. The estuarine regions of Amapá are also beginning to supply açaí fruit to Belém, the principal market. Although further away, they are able to ship the perishable fruit by packing them on ice in fishing boats with insulated holds (Smith, in press).

Açaí-based agroforestry systems occupy a particular economic niche in that they provide a product which is highly in demand in a major population center. On Combu Island, 1.5 km from Belém, the sale of açaí is the principal component of household incomes, which annually average more than US$ 4000 (Anderson and Ioris, 1992). Açaí stands are also exploited for palm hearts. In 1995, total Brazilian production of palm hearts was estimated at 20,653 metric tons, of which Pará produced 82% and Amapá 10.8% (IBGE, 1998).

While the açaí-based systems in Pará have been pointed out as examples of possible alternatives to slash-and-burn agriculture, their peculiar situation must be kept in mind: they are very close to a major urban market, guaranteeing good value and ease of transportation, and they occur in a fertile flood plain soils which can sustain large harvests without nutrient depletion. To some extent, the açaí-based systems of the estuary have a closer resemblance to forms of natural forest management than to planted agroforestry systems, because they represent a forest which has been heavily manipulated towards economic species. Açaí in the estuary, and the other species managed along with it, are present as components of the forest, and are not recent introductions.

Although not as important commercially as açaí in the estuarine region, forms of land use which involve the açaí palm can be found in other parts of Pará. These systems are the result of the commercial demand for açaí, but they lack the management finesse which characterizes the estuarine region. In their reserve along the Transamazon Highway, the Parakanã Indians, for example, simply harvest açaí fruit from naturally occurring stands, without any management practices. On settler's properties and ranches along the Transamazon Highway, açaí stands are also exploited for palm hearts, with methods ranging from clearcutting to more conservative selection. In the future, though, we may see new forms of management evolving in this and other regions, as farmers become more aware of the economic opportunities for açaí.

Plantations of Shaded Commodity Crops

Shaded perennial crops have become an important component of farming systems for settlers in frontier regions of Amazonia. In a survey of 144 farms near the Transamazon Highway, in the municipality of Uruará, Pará, Veiga et al. (1996) found that although pasture was the predominant land use, farmers devoted an average of 4.4 ha to perennial crops, equivalent to approximately 10% of the area under cultivation (or deforested) in the case of a standard 100 ha lot. In terms of frequency, the most important perennials were black pepper (*Piper nigrum* L.), planted by 72% of the farmers, coffee (planted by 51%), cacao (planted by 41%), and cupuaçu (planted by 12%). In terms of the total land area planted to perennials in the properties surveyed, cacao was the most important, with 66% of the area , averaging 2.9 ha per farm, followed by black pepper (16%) and coffee (14%). Revenues from perennial crops was found to be the primary source of cash for the purchase of cattle, or alternatively, for reinvestment in plantations. Manure was generally the only soil amendment used when perennial crops were first planted and in subsequent fertilizations.

A similar study by Walker et al. (1997) along the Altamira portion of the Transamazon Highway found the majority of the farmers in the region engaging to some extent in cultivation of perennial crops, mainly cacao, black pepper and coffee. Three-quarters of the farmers surveyed reported devoting some portion of their time to perennial crops, in addition to their activities with annual crops and cattle. In terms of economic success, the survey found that farmers who used agroforestry systems (considered as farmers who devoted $\geq$ 50% of their time to perennial crops) were better off than those who concentrated on annual crops or cattle.

In Acre, McGrath (1998) found similar economic benefits for farmers who had adopted perennial systems. In her study, greater household incomes for such farmers were associated with improvements in housing (substitution of thatch roofs), investments in cattle, and acquisition of equipment such as diesel generators and satellite dishes.

The long-term outlook for shaded perennial commodity crops in Amazonia may not necessarily be rosy. As Fearnside (1992) points out, Brazilian Amazonia is so large that if a significant portion were planted to such crops, world markets could become saturated, causing drops in prices. At the same time, many commodity crops are afflicted by various kinds of diseases or pests, and if prices drop steeply, farmers will be less inclined to invest in control measures, further exacerbating such problems. It remains to be seen if agricultural research and extension agencies will be able to respond to such a scenario, either with disease-resistant cultivars or alternative management practices.

The principal shaded perennial crops will be discussed separately in the following sections. Particular attention will be given to the historical trajectory of cacao, as it is an example of a native forest tree which was apparently cultivated or managed in Amazonia prior to the arrival of Europeans, and maintains its importance until today.

Cacao

Cacao was one of the first products to be exported in quantity from the Amazon by the Portuguese. Although the use of the cacao bean was first brought to the attention of Europeans during the Spanish conquest of Mesoamerica, the origin of cacao is in Amazonia. It is commonly stated in the literature that although cacao is Amazonian in origin, it was domesticated in Mesoamerica (Clement, 1994; Piperno and Pearsall, 1998; Schultes, 1984; Stone, 1984). This is founded on the lack of any evidence that pre-Columbian Amazonians used cacao beans in any way. However, even if Amazonian populations were totally unaware of the use of cacao seeds, the appreciation of the sweet pulp that surrounds the seeds could have been sufficient to motivate its cultivation and eventual dispersal to distant regions.

At the beginning of the colonial period, cacao was found to occur in high density along the Amazon and its tributaries. The great amounts of cacao which the Portuguese exported from Belém in the beginning of the eighteenth century were almost entirely from stands of "wild" trees, whose distribution oddly coincides with the areas occupied by the great chiefdoms encountered by the first Europeans to travel the Amazon. According to Alden (1976), wild or feral cacao appeared to be omnipresent, and "was found along the banks and the adjacent islands of the main river, both in its lower reaches near Belém and especially between its confluence with the Rio Tocantins and the upriver ports of Óbidos and Santarém, as well as along the margins of its major tributaries, particularly the Rio Negro, the Rio Trombetas (where Orellana had his encounter with the Amazons), the Madeira, and the Solimões." French traveler Charles de la Condamine found cacao growing wild along both banks of the Marañon River in Peru in 1739, and noted that the Indians gave it little attention (Condamine, 1944). In reviewing the historical evidence on the widespread occurrence of cacao, Smith (1999) concludes that it was likely planted by indigenous people on the Amazon floodplain.

Between 1678 and 1681, the Portuguese government took several measures to encourage the export of cacao from Amazonia. Although these measures consisted mainly of fiscal incentives, also included was the establishment of demonstration orchards near Belém. However, when exports of cacao did pick up, three and a half decades later, they came primarily from wild or feral trees. The methods used in the cacao harvest were similar to those used for the extraction of other forest products: collecting expeditions would set out upriver in large canoes, manned by a crew of Indian paddlers and supervised by a white or mixed blood master. From a central encampment they would spread out to harvest the cacao, bringing it back to be dried. Despite low quality, due to improper drying and storage and the inclusion of green beans, by the 1730's cacao had become the dominant export from the Amazon, and remained so for more than a century (Alden, 1976).

By the nineteenth century, the cacao gathering expeditions had ceased and cacao was being cultivated in plantations along the Amazon. Father João Daniel, writing in the mid- eighteenth century, described how farmers grew seedlings on raised beds for a year, then transplanted them out to the manioc fields, where banana trees had been previously planted to provide shade. He also mentioned that a number of fruit trees, such as orange, avocado, biribá, and others were also interplanted, as it was known that cacao produced better in their shade (Daniel, 1976). By the end of the nineteenth century, however, production had shifted to southern Bahia, and the Amazon region was preoccupied with the boom in the extraction of rubber, another forest product.

In more recent times, cacao cultivation in Amazonia has seen several cycles of renewed interest. However, as the main axes of frontier development in the last decades have accompanied the constructions of roads, cacao cultivation has left the *várzeas* or flood plains of the Amazon and become more important on the *terra firme* interfluves. When the Transamazon Highway was opened in the early 1970s, soil surveys indicated the occurrence of patches of "terra roxa" (alfisols) in the vicinity of Altamira, Pará. These soils are higher in fertility than most soils in Amazonia (excluding the *várzeas*) and are suited to the cultivation of a number of crops. CEPLAC, the Brazilian cacao board, actively supported the expansion of cacao in this region. In Rondônia, although soils are generally inferior in fertility, settlers who arrived in the colonization boom of the late 1970s and early 1980s were encouraged to plant cacao in order to stabilize their income. It is estimated that during this period approximately 90,000 ha of cacao were planted in Amazonia, principally in Rondônia (Alvim, 1989). However, in the early 1990s the price of cacao fell abruptly, with an approximately 70% difference from prices during the peak in 1977 and 1978 (Smith et al., 1995). With the concurrent drop in coffee prices, many farmers became disillusioned with their plantations. According to Smith et al. (1996) farmers pursued three main options: (1) neglect plantations until prices improve; (2) replace groves with other crops, such as cotton or pasture; and (3) intercrop with other perennials. In this last option, besides fruit trees, timber species were also planted, principally mahogany (*Swietenia macrophylla* King), cedar (*Cedrela odorata* L.), freijó (*Cordia* spp.), ipê (*Tabebuia* sp.), and pinho cuiabano (*Schizolobium amazonicum* Huber ex Ducke).

The recent partial recovery in the prices of both coffee and cacao has led to increased interest in these crops, both on the part of farmers and government officials. In order to support this new push towards cacao, CEPLAC's center near Belém has been active in selecting clones resistant to witches' broom (*Crinipellis perniciosa*). In 1998, the Municipality of Novo Repartimento, Pará, with funding from the Bank of Amazonia (BASA) and technical assistance from CEPLAC, began promoting agroforestry systems among small-scale farmers. These systems consist of combinations of a commodity crop such as cacao or coffee, intercropped with banana and timber trees, or peach palm. After a period in which CEPLAC obliged farmers to use only legume trees such as *Erythrina* and *Clitoria* for shade, CEPLAC officials have now accepted that timber trees can be an important contribution to the economic viability of cacao systems. Recent studies have indicated that mahogany trees grown under the shade of cacao will develop straight boles despite attacks by the shoot-borer (*Hypsipila grandella*; Melo, 1998).

Coffee

Although coffee is not native to Amazonia, its cultivation in the region received almost as much attention as did cacao in colonial times. Along with cacao, Father João Daniel lists it as one of the crops planted by the Portuguese colonists (with the help of enslaved Indians) in the mid 18th century (Daniel, 1976). Lieutenant-Captain Lourenço da Silva Araújo e Amazonas, in his *Dicionário Topográfico, Histórico, Descritivo do*

Alto Amazonas, *(1852)*, lists coffee as one of the main agricultural exports of the province, along with cotton, cacao, guaraná, and tobacco (Amazonas, 1984). Coffee production in Amazonia has followed a similar trajectory to that of cacao, suffering an almost complete decline with the expansion of cultivation in other parts of Brazil, in this case the states of Rio de Janeiro, São Paulo and Minas Gerais, and then regaining importance in the last three decades of the 20th century with the boom in frontier colonization. Agronomic research identifying "Robusta" coffee (*Coffea canephora*) as better adapted to tropical climates has played an important role in this recovery. A recent survey of small-scale farmers in the Pedro Peixoto colonization project in Acre found that coffee planting is increasing as a land use, either in the form of agroforestry systems or as a monoculture (Rocha, 2000). In the state of Pará, the Municipality of Novo Repartimento, with funding from the Bank of Amazonia (BASA) established a nursery with the goal of producing one million coffee seedlings to be planted by small-scale farmers, starting in 1998.

Oil Palm

The cultivation of African oil palm (*Elaeis guineensis* Jacq.) has been associated with large entrepreneurial undertakings, generally funded by SUDAM (Superintendência de Desenvolvimento da Amazônia). In Pará, the firm Agropalma owns 30,000 ha of plantations in the municipalities of Tailândia, Moju and Acará, and has plans to plant another 4000 ha in 2001 (Globo Rural, 2001). Such enterprises practice the monoculture of oil palm, grown in full sun, and generally have their own processing facilities in order to be economically viable. In the case of some plantations in Malaysia, oil palm is intercropped with rubber, but similar systems do not exist commercially in Brazil. Embrapa of Manaus, Amazonas, however, is now undertaking an extension project with small scale farmers in the Urubu River region, with the aim of establishing 5 ha of oil palms per family. This size of oil palm plantation can be managed by one family, and processing will be carried out at a cooperative (R. Miranda, pers. com. 1999).

Black pepper

In 1997, Brazil produced 9% of the world's commercial crop of black pepper, a quantity of approximately 13,000 tons, of which approximately 77% was produced in the state of Pará. However, harvests have been dropping since 1991, when Brazil produced 48,000 tons. According to Okajima (1997), despite the fact that Brazil has the most advanced techniques for the cultivation of black pepper, economic policies and high costs of production and commercialization have led to this decline in production.

Black pepper cultivation was pioneered in the region of Tomé-Açu, Pará, by Japanese immigrant farmers who obtained improved germplasm from Singapore in the 1930s. In response to a sharp post-WW II rise in prices, increased production of this crop began in 1952, and soon was responsible for unequaled prosperity in this immigrant colony. However, by 1957 plantations began to be affected by Fusarium wilt (caused by *Fusarium solani* f.sp. *piperis*) and by 1970, black pepper cultivation resembled an itinerant activity, with new plantations being established only in locations which had not had this crop before and were thus free of the disease. The crisis of what had been previously been called "black gold" forced the Japanese colony to search for alternatives and diversify production systems to include other crops such as papaya, cacao, oil palm, passion fruit, citrus, as well as cattle (Homma, 1998). Black pepper is still cultivated at Tomé-açu, now more commonly as a component in sequential agroforestry systems. These are discussed in the section on agroforestry systems developed by the Japanese-Brazilian in Tomé-açu. Following the success of the Japanese immigrants at Tomé-açu, black pepper was widely adopted as a crop among farmers in other parts of Pará. Today, black pepper has become an important perennial crop for small scale farmers along the Transamazon (Walker et al., 1997).

Discussion of Shaded Perennial Systems

There are very important differences between home garden agroforestry systems and systems based on shaded perennials, principally with regard to the nutrient status of trees. While the areas surrounding dwellings receive frequent inputs of nutrients in various forms, this is not the case for more distant fields. Although trees may be more efficient in absorbing nutrients and exploring more of the soil profile, when compared to annual crops, this may not be enough to guarantee their adequate growth and production, and also make up for exports in crop harvests. In Amazonia, little research has been done on nutrient budgets in shaded perennial systems of the most common crops such as cacao and coffee.

In some locations, such as Rondônia, there has been an increased tendency for farmers to plant crops such as coffee in the form of monocultures. However, the socioeconomic situation of small scale farmers may be more conducive towards the use of mixed systems with shade trees. In the state of Acre, some findings indicate that labor constraints have a great influence on the farmer's choice of activities and forms of management. According to Miranda et al. (1998), farmers are aware that coffee grown under the shade of *Inga* is less productive than that grown under full sun, however, such shade systems may be preferred because they require much less labor expenditure for weeding throughout the year. In the neighboring state of Rondônia, McGrath (1998) found that although farmers were conscious of the benefits of growing legumes such as *Mucuna* along with tree crops, this practice was eventually abandoned due to its high labor demands, and the fire hazard posed by dead vines in the dry season.

Agroforestry Systems Developed by Japanese-Brazilians in Tomé-açu, Pará

The agroforestry systems developed by Japanese immigrants who established an agricultural colony in Pará have been pointed out as examples of successful small scale commercial agriculture. Along with other traditional systems, they have been indicated as having the potential to provide new directions in the search for more sustainable land-use systems (Subler and Uhl, 1990).

According to Yamada (1999) the agroforestry systems employed by the Tomé-açu colony have arisen out of more than 30 years of trial and error experimentation. These systems developed at Tomé-açu were not just the results of the adaptation of Japanese farming techniques or agricultural concepts but of the commitment of individuals to developing an empirical basis for agroforestry, based on the observation of natural ecosystems as well as traditional Amazonian farming systems. Included in this effort was the experimentation with a vast number of tree species, both native and introduced, as well as different kinds of cropping systems. In Yamada's opinion, the problems with black pepper (discussed in the section on perennial crops) played a principal role in the development and fine-tuning of sequential agroforestry systems. When black pepper plants died due to Fusarium wilt, farmers were loath to let their fields go back to bush, so instead they planted cacao in the fertilized spots which had been occupied by pepper. At the same time, they experimented with intercropping annuals and other perennials such as papaya. As pepper plants could be expected to die after the fifth or sixth year, farmers began to plan for this eventuality, planting fruit and other trees such as mahogany between rows. When the pepper died, they planted passion fruit vines in every other pit, and trellis wires were attached to the posts which had once supported black pepper. In this system, passion fruit production was possible for at least three years before the trees began to cast excessive shade.

Another contributor to Tomé-açu's success has been the ability of the Japanese-Brazilian farmers to obtain better marketing conditions through their strong cooperative. This cooperative arose out of a history of difficulties, struggle, and hard work, and by the identification with a homeland and a cultural identity, despite a certain sense of abandonment which the colonists felt with regard to their mother country. Members of the cooperative were active in seeking out new crops and germplasm, and the cooperative itself was able to secure financing enabling it to move into processing, through the construction of a plant to extract oils and oleo-resins from spices, in 1963, and a juice factory in 1987 (Yamada, 1999).

Despite the success of the Japanese-Brazilians, and the adoption of their methods by neighboring farmers in the region, their reliance on chemical fertilizers may make this success difficult to reproduce for farmers in frontier regions, who have limited access to such inputs. Nevertheless, their attention to the use and management of organic matter is something that should be recommended to other farmers.

Silvopastoral Systems

There is scant information in the literature about silvopastoral systems in Amazonia. Most grazing systems in Amazonia are extensive, and the widespread practice of periodically using fire to clean pastures can be a limiting factor to tree survival in such situations. Even on research stations, escaped fires have destroyed experimental silvopastoral systems (Townsend et al., 1998; Veiga and Marques, 1998). Establishing trees in existing pasture lands in Amazonia is extremely difficult, as several studies have shown. Kainer (1997) planted Brazil nut in three different environments on rubber tapper holdings in Acre, and found that growth of seedlings was lower in pastures than in forest gaps and slash-and-burn agriculture fields. Fencing with low cost materials obtained from the surrounding forest was not sufficient to protect seedlings from being pulled up by cattle. Overall, planting seedlings in pasture required greater labor expenditures on the part of the landholder than planting in the other environments. Establishing trees in degraded and abandoned pastures is also a difficult task. Nepstad et al. (1990) found that the chief factors which limited success of this enterprise were competition by pasture vegetation for scarce soil resources, the presence of fire, and predation by leaf-cutter ants (*Atta sexdens*).

Scattered trees which survive clearing are sometimes left in pastures to provide shade for cattle. Although most of the breeds currently employed in Amazonia for beef production are of predominantly Indian origin, and are quite heat adapted, dairy cattle generally are of mixed European-Indian blood, and the provision of shade can be beneficial to milk production. Research in Australia found that shade can reduce heat stress in cattle, with positive effects on production (Blackshaw and Blackshaw, 1994)

More intensive systems in which trees are used to provide fodder are practically unknown in the Brazilian Amazon, despite the potential of legume trees to provide supplemental protein during the dry season, when nutrient content of pasture grasses declines significantly. Near Manacapuru, in Amazonas State, one farmer was observed lopping *Inga edulis* as fodder for his cows, perhaps influenced by INPA researchers who have assisted him with an agroforestry experiment.

Less Common Systems

It is likely that there exist interesting agroforestry systems which have not yet been described in the scientific literature. For example, farmers in Maués, Amazonas, a region which has traditionally supplied the bulk of the guaraná produced in the state, are reported to plant Brazil nut trees to provide shading for the guaraná plants (S. Garcia, pers. comm., 1999). This system may be the result of Japanese influence in that region, as there was a Japanese settlement in Maués prior to World War II.

The use of trees to make living fenceposts is not common in Amazonia, perhaps for the same reason that silvopastoral systems are infrequent, namely, due to the periodic use of fire to clean pastures. They may have been more important during colonial times, when nails were dear and barbed wire did not exist. Father João Daniel, for example, recorded his observations on living fences in use on Marajó Island at the mouth of the Amazon during the colonial period. Corrals were made by setting pairs of live stakes (species not identified) in the ground along the desired fence line. Once these became established, cross pieces of hardwood were stacked up between the pairs to build the fence (Daniel, 1976). The use of trees as living fence posts can still be observed along the banks of the Middle Amazon, particularly where the fences represent property boundaries. The principal species used is munguba (*Pseudobombax munguba*), a native species of the *várzea*. Although it can be grown from cuttings, it is more common for seedlings to be obtained from beneath a parent tree and then planted at a 50 cm spacing. Other species which may also be used are macacaúba (*Platymiscium sp.*), taberebá or hogplum (*Spondias mombin* L.*)*, rubber, genipap, and the calabash tree. Of these, the taperebá and calabash tree are planted from cuttings. Although the tendency of the calabash tree is to have spreading branches, with pruning a tight hedge of intertwined branches is obtained. Smith (1999) describes a living fence of hogplum on a farm in the Santarém region, used to contain cattle.

Conclusions

The most traditional agroforestry systems in Amazonia are forms of home gardens of fruit trees and other useful plants, with origins perhaps dating to the dawn of agriculture in the region. Today, home gardens are valuable components of household livelihood systems, contributing mostly to domestic consumption. More research on home gardens is needed to determine the constraints involved in expanding or further developing them for greater productivity and income generation. Such new systems could resemble the traditional systems in a number of ways, but most likely would involve an entirely different configuration of limitations and constraints with regard to nutrient exports and labor requirements.

It is clear that specific agroforestry research and extension goals must be defined for Amazonia, based on particular land use patterns and problems, and not simply by expanding existing agendas developed elsewhere. The potential of existing systems should be taken into account in this process. There exists a considerable diversity of agroforestry systems in Amazonia, whether traditional or of recent development. Agroforestry has only recently been introduced into the curricula of foresters and agronomists who are trained in the universities of the region. They need to gain an understanding of these existing systems as a starting point or baseline for future efforts in research and extension. In this way, knowledge will be incorporated by a group of people who will have influence in the future as professionals and policymakers.

CHAPTER 4

THE STUDY SITE: A DESCRIPTION OF EASTERN PARAKANÃ COMMUNITIES, THEIR HISTORY AND PHYSICAL SETTING

History

The most complete single source of information on the history of the Parakanã is Fausto's (1997) PhD dissertation, which combines information from historical documents and other literature with oral histories obtained from elderly Parakanã. The Parakanã Indians are of the Tupi language group and are believed to have descended from tribes which lived on the northeastern coast of Brazil. With the "discovery" of Brazil in 1500, and subsequent colonization by the Portuguese, these coastal tribes became increasingly subject to epidemics and slavery, and as a result, many fled to interior regions such as the Tocantins valley in Pará. It is thought that the ancestors of the Parakanã established themselves in a region between the Tocantins and Xingu Rivers, southeast of Belém, Pará, and this became their traditional territory sometime before 1600. However, their respite from the colonizer was brief, as between 1600 and 1700 missions were established on the lower Tocantins, and the Tocantins valley was penetrated by missionaries and military expeditions involved in the capture of Indians for slaves. By 1800, these activities, along with epidemics of diseases such as measles and smallpox, resulted in a greatly reduced Indian population in the region. The Tupi-speaking peoples of the

Tocantins valley fragmented into separate bands, with little intergroup contact other than warfare. The ethnic group known today as the Parakanã is itself constituted of two groups which Fausto (1997) terms the Eastern and Western Parakanã, who separated sometime around 1890 following internal conflicts.

After the fission of the Parakanã into two groups, there was a gradual shift in cultural habits. The Eastern Parakanã continued to rely heavily on agriculture, while the Western Parakanã would establish a sort of base with a manioc plantation, but spend most of their time in trekking. Supposedly, the introduction of steel tools, obtained through trades or raids, rather than leading to a greater involvement in agriculture, in fact allowed the Western Parakanã more time for trekking. In the 1940s and 1950s, trekking was associated with raids on the villages and gardens of the Eastern Parakanã to obtain manioc.

The Parakanã's situation of relative isolation continued until around 1900, when the government of Pará became interested in opening up extractive fronts for rubber-tapping and colonizing the Tocantins region. In 1905, construction of the Tocantins Railway was begun in Alcobaça (now Tucurui) as a way to transpose dangerous rapids impeding river navigation. By 1914, 58 km of railroad had been constructed, but then, with the crash of the rubber boom in 1917, work was halted. In the mid 1920s, however, construction was resumed due to the increasing importance of Brazil nut exports. Besides Brazil nuts, the railroad also served to transport balata gum (from the latex of *Manilkara* spp.), as well as hides, salted meat, and cattle from the savannas of Maranhão. Due to attacks by Indians on the construction crews, in 1928 the S.P.I. (Brazilian Service for Indian Protection) established the Tocantins Pacification Post at km 67 of the railroad. It is likely that the Indians responsible for the attacks were not the Parakanã but the Assurini[6]. Regular contacts of the Western Parakanã with Brazilian society occurred in the early 1930s, and were relatively peaceful. They would visit the Post to trade tortoises and other animals for goods such as machetes, axes, and cloth hammocks. According to Arnaud (1983), this contact brought a measles epidemic and many deaths to the Parakanã, with the result that they disappeared from view in 1938, only reestablishing intermittent contacts again in 1953. Fausto (1997), however, contests this version of history, and suggests that the Parakanã's disappearance was related to the fact that they had become so well stocked with metal tools that they were free to engage in a cycle of trekking migrations to the west.

Around 1960, economic penetration by the extractivist frontier began to come closer to the Parakanã. Loggers moved up streams and cut trees to be floated out in the rainy season, and it was possible that spotted cat hunters also exploited the region. The Parakanã had some violent encounters with these elements, who were generally much better armed, and there was a gradual closing in of the territory available for their lifestyle of trekking. In the late 1960s, a group of Western Parakanã had a violent encounter with the Xikrin-Kayapó Indians near the Bacajá River, and 13 of their members were either killed or captured. The pattern of infrequent contacts between the Parakanã and Brazilian society changed greatly in the 1970s, with the construction of the Transamazon Highway, part of a bold plan by the Brazilian government to open up Amazonia for development. In order to avoid a repetition of the problems which occurred during the construction of the Tocantins Railway, the recently-created FUNAI took a more aggressive stance towards the pacification of the Parakanã. Rather than going through a slow process of "courting" which involved leaving gifts in a neutral location, and establishing friendly relations, expeditions to contact the Parakanã actively sought out villages to distribute gifts in an attempt to speed up their removal from the path of the highway. One expedition chased a fleeing group, stricken by sickness, through miles of forest. In October of 1971, the Eastern Parakanã were moved to a FUNAI camp, where contacts with workers at nearby construction camps led to sicknesses such as flu, venereal diseases, polio, and hepatitis, with disastrous effects on their population. Despite the creation of a Parakanã reserve in 1971, invasions and contact with highway workers continued, with the result that during a visit by a medical doctor in that same year, 35 Indian women were found to be contaminated with venereal disease (Davis, 1980). Between 1971 and 1977, this group of Eastern Parakanã was relocated four times by FUNAI.

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[6] The Assurini now live 15 km north of Tucurui, on a small reserve crossed by the Transcametá Highway (see Fig. 1-2).

In May of 1972, FUNAI established contact with the Western Parakanã. Following internal strife in 1975, the bulk of the group had moved approximately 250 km to the west, into the basin of the Xingú River. In January 1976, the 40 remaining Western Parakanã appeared at a construction camp at km 377 of the Transamazon Highway, and were transferred to the Pucuruí Post (the old Tocantins Attraction Post). Of this group, a number died of illness. In the following years, the Western Parakanã who were still living in the forest had conflicts with the Araweté and Xikrin Indians, as well as ranchers, loggers, and prospectors from the agricultural and extractive frontier advancing from the region of Tucumã to the south. In 1977, a group of isolated Parakanã was contacted while fleeing from a massacre by the Xikrin-Kayapó and was relocated to a camp near a FUNAI post (Arnaud, 1983). In 1980-1982, the Western Parakanã made several raids on ranches, prompting FUNAI to attempt contact with them. A group of 44 was contacted and transferred to Maroxewara village in the Parakanã Reserve. Eleven died within the next six months. In 1984 the remaining Western Parakanã were also contacted and eventually settled around the Apyterewa-Parakanã Post, near the Xingú River.

The two groups of Parakanã (Eastern and Western) living in the Parakanã Reserve were forced to move again in 1984 when portions of the reserve were flooded by Tucuruí Dam on the Tocantins River. A new reserve was officially demarcated in 1987, but their general situation only began to improve when a cooperative agreement between FUNAI and Eletronorte was put into effect, creating the Programa Parakanã, which would mitigate the impacts of Tucuruí Dam on the Parakanã. This program, although established in 1988, only began to operate effectively in 1991, with the removal of FUNAI employees and the contracting of new personnel. Although the Programa Parakanã has reduced the infant and general mortality rate almost by half, and vaccination for a number of diseases is routine, it continues to struggle with problems related to nutrition, intestinal parasites, and certain diseases. While malaria vectors are controlled around the villages, community members may become infected when they camp near the Transamazon Highway in order to collect extractive products. Through its

Environmental Protection Subprogram, and with the help of community members, the Programa Parakanã has been able to maintain the reserve relatively free of intruders such as loggers, prospectors, and hunters. The Education Subprogram, which currently has schools in the five villages, works with literacy in the Parakanã language and Portuguese. The Programa Parakanã also assists the community in transporting and marketing agricultural and extractive products, using three Toyota four-wheel drive vehicles and one seven-ton truck.

Besides the population of Parakanã occupying the reserve described above, another 214 individuals live on the Apyterewa Reserve (no. 11 on Fig. 1-2), distant approximately 150 km from the Parakanã Reserve. There is, however, little contact between the populations of these two reserves, and the Apyterewa Reserve was not be included in the present study for logistical reasons.

The story of the Parakanã and their coming out of the forest is not over yet. In early 1998, Warerá, one of the leaders of Paranatinga village, was called to the radio to speak with the Parakanã of the Apyterewa Reserve. They communicated to him that a relative of his had come out of isolation in the forest and had been taken to the village. While Warerá was making preparations for a journey to the Apyterewa Reserve to meet this individual, he fled once more to the forest.

Political Structure

The Parakanã of the Parakanã Reserve number 513 individuals (as of January 2001), distributed in five villages. In terms of kinship and social history, the population is divided into two distinct groups, the Eastern and Western Parakanã, between which there is little intermarriage. When these two groups were transferred to their present location due to flooding caused by the Tucuruí Dam, they each founded a new village, Maroexewara for the Western Parakanã and Paranatinga for the Eastern Parakanã. Subsequently, each of these villages fissioned, creating new villages, Inaxianga (from Maroexewara) and Paranawaona (from Paranatinga). Paranatinga fissioned again in 1998 when 50 members left to establish the village of Itaygo'a. on the Bacuri River, distant 11 km by access road from the Transamazon Highway. By 2000, better living conditions at this new village prompted more families to move out of Paranatinga. Division of villages to create new ones is the result of the confluence of a number of factors, which include internal political dissent as well as increasing scarcity of game animals and other resources in the vicinity of the older village.

Villages are divided into extended family groups representing patriarchal lineages. According to Fausto (1997), these "production groups" are constituted around an older male and are represented by a younger leader. In 1992, for example, the groups at Paranatinga village were the following:

- Moxiapewa
- Warera
- Ipirakyge

- Awapi'ia
- Wararoa

After the exit of Moxiapewa, Ipirakyge and Awapi'ia to found the village of Paranowaona, Paranatinga reconstituted itself politically with the following leaders of groups: Warera, Monewa, and Axoa. While each village may have a communal agricultural field, the groups within the village also have their own separate fields. The group leaders are responsible for selling the production of Brazil nuts, rice and maize, and for representing their group on the bimonthly shopping trips to Tucurui. With regard to the sale of agricultural and extractive products, however, there has been an increasing participation of younger individuals with math skills, who are responsible for the accounting. Although villages have internal divisions along kinship lines, all adult males meet together in the evenings at a designated site, called the *tekatawa,* to smoke tobacco and discuss village affairs. While all the Eastern Parakanã lived in one village (Paranatinga) they deferred to the aged, semi-blind patriarch Arakyta as the "*capitão*" (captain). Although this term was often used in the past by FUNAI employees when they designated individuals to represent a community (at times disrespecting existing political hierarchies), Arakyta is consulted in all matters referring to Parakanã culture, such as festivals and rituals. Arakyta's prestige is exploited by his son Warera, who despite physical handicaps, is the principal leader of Paranatinga. Paranowaona, the first village to split off from Paranatinga, is led by the energetic leader Moxiapewa, whose uncle Pykawa has taken over the role of cultural leader, and is responsible for conducting the *tekatawa* in that village. In the case of Itaygo'a village, the *capitão* is Ywyrapytra, father of the principal leader Xawatirona. Despite the factors which led to the splitting and establishment of new villages, the presence of close relatives means that all three villages maintain close ties. It was common to see land tortoises, a favorite food of the Parakanã, being sent from Paranawaona to Paranatinga (where they have become scarce) whenever there were trips between these two locations, and then later from Itaygo'a to Paranatinga. When there was scarcity of manioc in Paranatinga or Itaygo'a, processed manioc meal was sent from Paranowaona, where there was a surplus.

As mentioned before, there is very little social interaction between the Eastern and Western Parakanã who inhabit the Parakanã Reserve. Besides their historical differences, the two groups differ in the form of their relationships with surrounding society. While the Eastern Parakanã have a great preocupation with the production of goods for sale, and a great attraction to consumer goods, the Western Parakanã are less dependent on the market, their main source of income being the sale of Brazil nuts. This, however, may be a chicken-and-egg question - access to Maroxewara and Inaxyganga is much more difficult than access to the Eastern Parakanã villages, so that even if they desired a greater relationship with the regional economy, this would be difficult to achieve. As a result, they may have no choice but to consume less manufactured items. This situation may change, however, in coming years, as the municipal government of Itupiranga plans to open new roads in the region, which will improve access to the villages.

General Description of a Parakanã Village

The Parakanã once lived in large communal houses, approximately 10 x 25 m in size. Today they live in smaller houses, based around nuclear family units. Most of the houses are built of local materials, and use the split trunks of the *paxiúba* palm (*Socratea exorrhiza* [Mart.] H.A. Wendl.) for wall and the leaves of the *babaçu* palm (*Attalea speciosa* [syn. *Orbignya phalerata*]) for roof thatching. The exception are some wooden houses in Paranatinga and Maroxewara villages, which were built following a promise by Eletronorte at the time of the transfer from the inundated area. This promise to build "regional" style houses with wooden walls, cement floors and shingle roofs is being fulfilled at a snail's pace by the Programa Parakanã. The possession of such houses, however, has not prevented families from moving away from these villages, even though the Programa Parakanã has made it clear that it will not continue to provide such houses in the new locations.

Physical Setting of the Parakanã Reserve

Geography and Vegetation

The Parakanã Indian Reserve is located in southeastern Pará, south of the city of Tucuruí and the town of Novo Repartimento (Fig. 1-2). The reserve occupies an area of 351,697 ha, covered almost entirely by mature tropical forest, with some small areas of secondary forest. Some of the emergent canopy species include Brazil nut (*Bertholletia excelsa*) and mahogany (*Swietenia macrophylla*). Babaçu palm (*Attalea speciosa*) is abundant in the region, especially in secondary forests. Relief is hilly, with occasional granitic boulders. The northeastern portion of the reserve is bounded by the Transamazon Highway and year-round access to Paranatinga village is possible by an 8 km access road off the highway. During the dry season, access to Paranowaona is by 60 km of side road. This road becomes impassable in the rainy season, and access to Paranowaona is only possible by aluminum skiff, which entails a journey of five to six hours on the Pucuruí River, from Paranatinga village or a bridge on the Transamazon. Travel to the villages of Maroxewara and Inaxyganga follows a similar pattern, with access by road in the dry season, and access by boat (on tributaries of the Cajazeiras River) in the rainy season. Alternatively, road access to these two villages in the rainy season can be by mules or horses. Access to the newest village, Itaygo'a, is by 12 km of side road off the Transamazon Highway, during the dry season, and by skiff on the Bacuri River in the rainy season. The climate is characterized by a distinct dry season of three months (July-September) or more, in which there is virtually no precipitation. Rainfall data for Marabá, approximately 150 km SE from the study site, are shown in Fig. 4-1.

Soils

Although no specific survey of the soils of the Parakanã Reserve has been carried out, several studies made nearby allow a general idea of the pedology of the region. Falesi's (1972) survey along the Transamazon Highway found a predominance of "Podzólico vermelho amarelo distrófico" soils in the Cajazeiras area, a town near the Reserve. This soil is equivalent to an Allic Haplustult in the U.S. soil taxonomy, or an Acrisol in the FAO-UNESCO classification (Eletronorte 1988). According to Brasil (1981), this soil occurs frequently on the left margins of the Tocantins River, where it is associated with "latossolos vermelho amarelo" (oxisols), lithic soils, cambisols and lateritic soils. It is considered a well-developed, acid soil, with a weak ochric A horizon and an argillic B horizon, and generally low fertility. Soil samples taken in various locations around Paranowaona village and one location at Paranatinga correspond to this description, with a sandy A horizon and an argillic B horizon appearing, in most cases, at 10-20 cm depth. Almost all samples had varying quantities of very small quartz pebbles appearing at all depths. Changes in soil characteristics along a 120 cm profile at Paranatinga village are illustrated in Figure 4-2. In this profile, a light brown sandy A horizon gives way to a reddish argillic B horizon at 50 cm depth, which becomes denser and with light mottles at 80 cm depth. More detailed information on the soil samples is given in Chapter 6 (Figs. 6-15,16 and 17) and in Appendix 1.

Included in the lithosols referred to in Brasil (1981) are various types of quartzite deposits. In 2000, mining was begun on a surface deposit of high grade white quartzite just across the Bacuri River from the village of Itaygo'a. This raw material is taken to the CCM plant in Breu Branco, across the Tocantins River from Tucuruí, for the production of silicon. At Paranowaona, several locations nearby the village show a occurrence of quartzite cobbles, with indications of an igneous dike.

Although the "terra roxa estruturada" or alfisol is more common on the stretch of Transamazon Highway near Altamira, there is an occurrence of this soil type just outside the Reserve, near the village of Paranowaona. It is possible that this soil type also exists in the lands of the Parakanã, as on satellite imagery, the geologic features associated with this patch of "terra roxa" can be seen continuing into the Reserve.

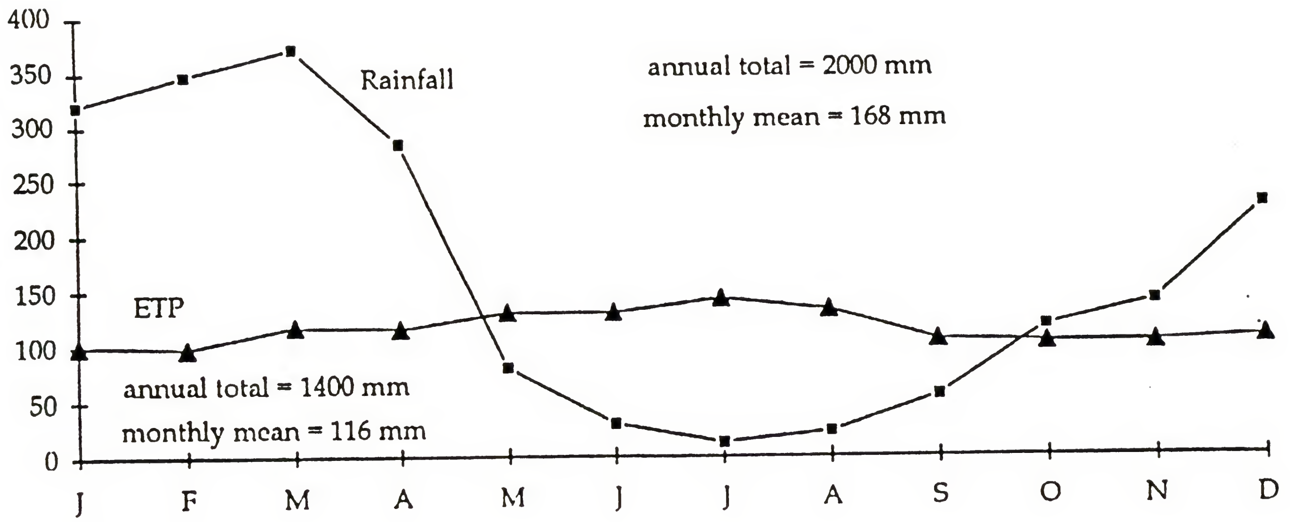

Figure 4-1 Rainfall and potential evapotranspiration in Marabá, Pará (monthly average for 1973-86). Source: de Reynal *et al.* (1995).

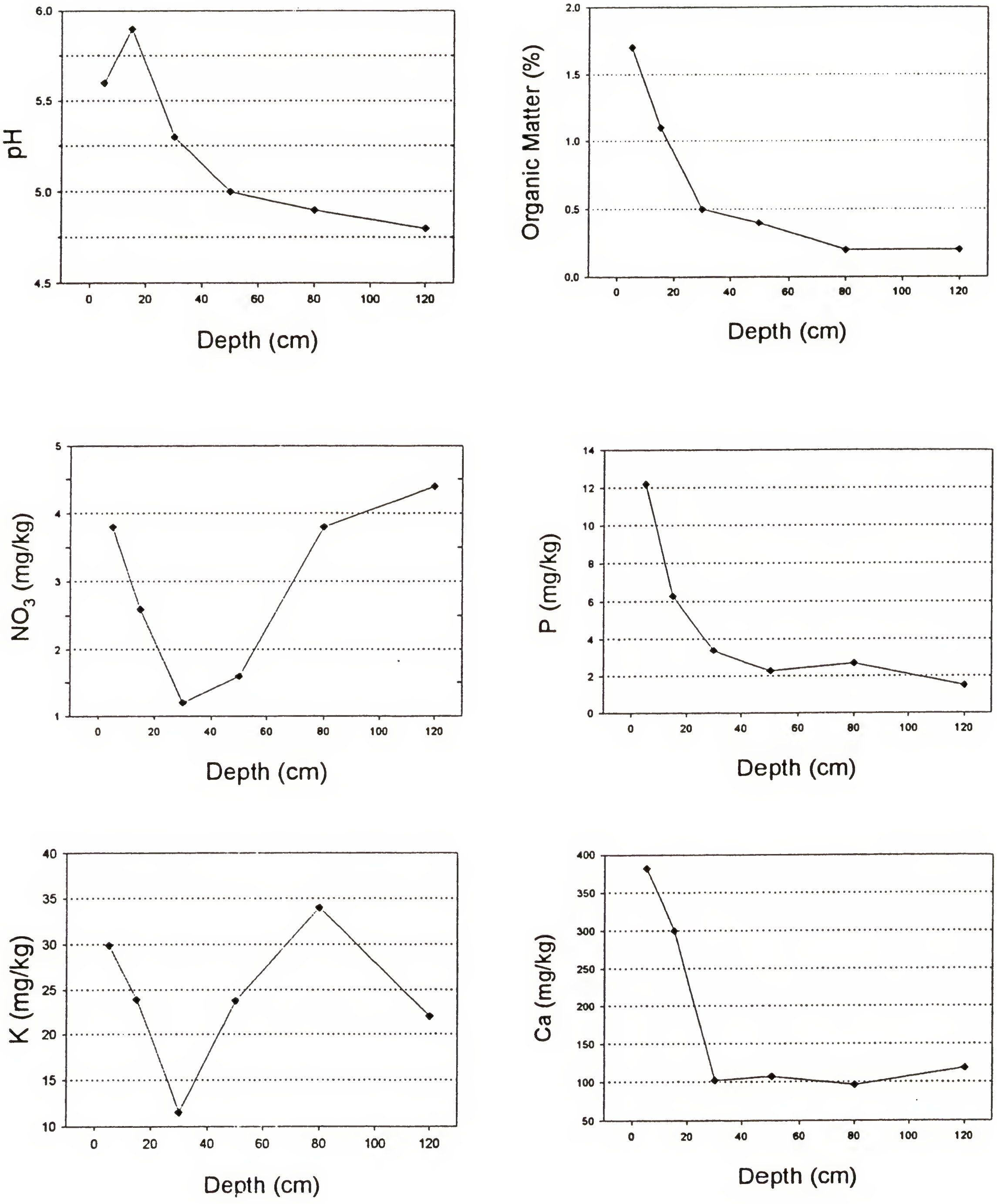

Figure 4-2: Principal chemical characteristics of a soil profile at Paranatinga village. Diamond symbols indicate sampling depths.

CHAPTER 5
EXTRACTIVE FOREST PRODUCTS IN THE ECONOMY OF THE EASTERN PARAKANÃ INDIANS OF PARÁ, BRAZIL

This chapter will examine the role of extractive forest products in the economy of the Parakanã Indians of southeastern Pará. Their use of forest products will be contrasted with the the use of such products by their neighbors, the settlers and ranchers established along the Transamazon Highway and its side roads. The opportunities and limitations in the use of these forest resources by the Parakanã and their neighbors will be examined in the context of their importance to forest conservation in the region.

Introduction

The economic viability of extractive or non-timber forest products has been an important issue in the debate on the conservation of Amazonian rainforests. During the last decades, extractive forest products such as rubber and Brazil nuts were the economic mainstays used to justify the legal creation of extensive extractive reserves for rubber-tapper families in the state of Acre, in Western Amazonia (Allegretti,1990). Hopes have been raised that extractive reserves will "reduce conflicts over land use and ownership, promote sustainable harvest of a variety of natural resources, and lessen pressures to clear undeveloped areas for farming...and will enable their residents both to maintain the integrity of portions of the Amazonian rainforest and to protect species habitat and biodiversity, while continuing to support themselves" (ELI 1995). Nonetheless, the long-term sustainability of an economy based on extractive products has been questioned by Homma (1992). In Homma's model, extractivism of forest products is only a phase in the economic development of a region, and if a given forest product proves to be of sufficient economic importance, the tendency is for it to be domesticated (generally, somewhere else) or substituted by a cheaper synthetic or alternative product. Thus, wholesale investment in extractive reserves may be an ineffective policy for economic development. However, Rego (1999) has suggested an alternative pathway to Homma's model through "neo-extractivism," a concept which encompasses the use of technical improvements in cultivation, harvesting and processing and processing of forest products, allied with the specific social environment of a "forest culture" of peoples whose lifestyle is intimately tied to the forest. Although Rego does not state this explicitly, it must also be considered that today's forest dweller lives in a political environment in which social justice is a greater concern. For a variety of reasons, both governments and civil society have interests in combining social justice with conservation, and can work towards compatible goals, as is presently occurring in Acre (Schmink, 1999). In the case of Acre, a mix of funding sources[7] has contributed R$ 3.8 million to finance factories for processing rubber latex and Brazil nuts in the municipalities of Brasiléia and Xapuri (Correio Braziliense, 2001).

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[7] World Wildlife Fund, the Acre state government, and the Banco Nacional de Desenvolvimento Econômico e Social (BNDES).

In order to use the economic potential of non-timber forest products as an argument for conserving tropical forests, some researchers have attempted to quantify actual production values. Determining what can be produced from a given area of forest, for example, would allow a comparison of the relative advantages of different forms of land use, say extractive production vs. conversion of forest to pasture, one of the chief causes of deforestation in Amazonia. A study carried out by Peters et al. (1989), and which received widespread attention, determined that one hectare of forest near Iquitos, Peru had the potential to produce an income of almost US $ 700/yr from the sale of fruit and latex. The NPV (net present value) of harvests was calculated as $ 6,330/ha. This value compares very favorably with conversion to pasture, for which a NPV of $ 2,960 was ascribed. However, a study carried out nearby to the Peters et al. site found that in a real-life situation only 2.5 to 3.5 % of the total available goods are actually harvested, so that yearly income from the forest might only be $ 15/ha (Padoch, 1992). In fact, the harvesting of forest products by rural households must compete with other essential activities such as subsistence agriculture, hunting and fishing, house and equipment maintenance, among others, and the marketing of perishable fruits in particular is greatly affected by the distance to markets. Other authors have pointed out that besides strictly economic decisions, a number of other factors can influence land-use choices. Fearnside (1990), for example, affirms that often the principal motive for planting pasture in Amazonia is its low cost and high effectiveness as a means of securing land claims. In Tomé-açu, Pará, Yamada (1999) found that although conversion of forest to pasture was the least lucrative land use for Japanese-Brazilian farmers, this activity continued to be a part of their land use portfolios. Farmers with less capital often are constrained to even fewer choices as to how to use their land, and pasture formation presents itself as the cheapest way for them to increase the value of their properties.

Despite the use of theoretical values, the study by Peters et al. drew attention to the important role of non-timber forest products in local economies. Other researchers have been inspired to pursue further the valuation of tropical forests as a means of influencing policy makers to include conservation as an economic option for development in forested regions. Anderson and Ioris (1992) for example, studied small-scale forest extractivists in the Amazon estuary and found that their average annual household income was greater than US$ 4000. However, it must be considered that their study site was 1.5 km from Belém, a major city, and forest composition in the region had been heavily manipulated towards economic species. In addition, their study site was located on a floodplain with no significant soil nutrient limitations.

Godoy and collaborators (1992, 1993a, 1993b,1995) have further explored the methodological issues involved in valuation of tropical forest, through their own work and in reviewing other studies. They point out a number of methodological pitfalls which afflict attempts at forest valuation, such as the difficulty in keeping track of items which people consume within their households, give away, or trade with other households. Even if the subjects were willing to write down all of these transactions, this data would still be questionable. As Bernard (1995) points out in his textbook on anthropological methods, generally one-half of what informants tell researchers is incorrect in some way. Given the difficulty in assigning values to forests based on their extractive products, we can almost conclude that the valuation of non-timber forest products comes near to being as "intangible" as the other products traditionally regarded as intangibles, such as watershed conservation, biodiversity preservation, and climatic amelioration, among others. Nevertheless, just as these intangibles have received serious consideration in the establishment of national and global forest policies, so too must the value and role of extractive products be appreciated.

This study of the extractive and agricultural economy of the Eastern Parakanã was conducted as a complement to an agroforestry extension project conducted under the auspices of the Parakanã Program. By concentrating only on those products which were actually sold, this study attempted to avoid the methodological pitfalls associated with ascribing economic values to items which may or may not be removed from the forest. The limitations on the communities' capacity to harvest and market forest products is discussed, along with the relevance of these products to discussions on the economic role of conserved forests.

Methods

Between January 1998 and September 2000, several extended periods totalling nine months were spent at the Parakanã Reserve, with occasional trips to the Program headquarters in Tucuruí. The study of the Parakanã economy was begun in May 1998, with information on all items which left the villages to be sold being recorded by non-Indian teachers and two drivers responsible for transporting community members and their goods to market. After the first year, data were gathered only by teachers, with the help of community members, and data collection was incorporated as part of the Programa Parakanã's routine. Records of large volume sales, as is the case for Brazil nuts, were already being kept by the Parakanã Program's office, and some data for other products were also available for a few years prior to the beginning of this study. These earlier records served to complement the data collected during this study.

General information about the Parakanã's hunting, gathering, agricultural, and extractive activities was obtained through participant observation and in conversations with employees of the Parakanã Program. Female employees were particularly important in this regard, as they could provide details about the activities of Parakanã women. Since only a few Parakanã women speak Portuguese, and given the the characteristics of Parakanã culture, obtaining information about women's activities would otherwise have been a difficult task.

Perceptions on the relative value of the different agricultural and extractive products and the amount of effort involved in their cultivation or harvesting were explored by means of a ranking exercise. This was carried out using cards illustrating each product, and was done in the school at three villages. Members of another village were interviewed while in Tucuruí.

Information concerning the role of forest products in the livelihood of settlers was obtained from Program employees whose families have pioneer lots in the region, as well as from observations and conversations with local residents during trips to the Reserve or between villages.

Results: The Economy of the Eastern Parakanã - Hunting, Gathering, Agriculture, Extractivism, and Consumption

In this section, the concept of "economy" is employed in a broad sense, to include both commercial transactions within a marketplace, as well as what may be considered "domestic economy", i.e. the supplying of daily household needs. We will begin, therefore, with a description of hunting and gathering as a component of Parakanã subsistence, followed by a description of agricultural activities, for both subsistence and sale, then by commercial extractivism. Finally, the purchase of manufactured goods from the proceeds of the sale of agricultural and extractive products will be discussed, along with its role in affecting decision making in the Parakanã economy.

Hunting and Fishing

Hunting activities among the Parakanã were the subject of a master's dissertation by Emidio Silva (1998). Most of the information presented here is drawn from that thesis. With the exception of a few older men, who use bows and arrows, hunting is done with 16 or 20 gauge shotguns. Preferred game animals are mammals such as deer (*Mazama americana* and *M. gouazoubira*), peccaries (*Tayassu pecari* and *T. tajacu*), tapirs (*Tapirus terrestris*), armadillos (*Dasypus* spp.), pacas (*Agouti paca*), and game birds such as the curassow (*Crax mitu* and *Mitu mitu*) and the jacú (*Penelope* sp.). Monkeys are sometimes hunted, but are said to be consumed only by older people. Although not strictly "hunted", land tortoises (*Geochelone carbonaria* and *G. denticulata*) are probably the single most important prey item for the Parakanã. Tortoises were particularly abundant around newly established villages where they were gathered in quantity and kept in pens. Another reptile, the caiman (*Caiman yacare*), is an important game item, and is generally captured on river outings. Mammals are often hunted at night, by waiting in stands next to trees whose fallen flowers or fruit attract game animals. Deer are sometimes found visiting abandoned fields to browse on the leaves of manioc or pioneer vegetation.

For most villages, fishing is more important in the dry season, when fish are concentrated in deeper portions of the rivers. In Paranatinga village, spawning runs at the beginning of the rainy season can provide large catches.

Gathering

Gathering forest products probably contributed much more to the Parakanã's diet in the past than it does nowadays. This is in part due to their present sedentarization into permanent villages and their greater attention to agriculture. Furthermore, some products, such as Brazil nuts and honey, are being saved for sale, so their consumption has also decreased, at least in some villages. Nevertheless, gathering of forest fruits and other products still represents an important contribution to the diet. While this aspect of the Parakanã economy was not studied quantitatively, some general observations can be made as to the relative importance of different foodstuffs. Perhaps the most important wild plant to women's foraging activities is the *babaçu*, a palm which is quite common in the region. Its large nuts contain three or more seeds which are rich in fatty oils. To extract the kernels, the nuts must be broken open between two rocks, or split by holding them over the blade of an axe and hitting them with a wooden mallet. Sometimes the seed cavity will be filled with the larva of a bruchid beetle. These are collected and taken back to the village to be cooked and eaten as a choice morsel, along with manioc meal. *Babaçu* palms are also felled to remove the apical meristem or palm heart. Although a good bit of axe work is required to get through the thick leaf bases, a single palm yields a sizeable amount of palm heart, which is prepared in the form of a gruel. Parakanã children in particular obtain a significant portion of their diet from foraging. Although no specific methodology was used to verify quantities, observations show that the following items are important:

- *babaçu* nuts and larvae (see above)
- germinating babaçu nuts
- larvae of a cerambycid beetle which develop in the fallen trunks of the mamuí tree (*Jacaratia spinosa* - Caricaceae)
- sweet potatoes
- fruits of banana, coconut, mango and other fruit trees planted around villages or Indian posts
- fruits of spontaneous guava trees
- fruits of the yellow mombin or hogplum (*Spondias mombin*), wild cacao (*Theobroma speciosum* Willd. ex Spreng.), and *inajá* (*Attalea maripa*) palms growing in the forest near villages

Adults will collect the fruits of the *uxí* tree (*Sacoglottis uchi* Huber) while hunting and bring them back to the village for consumption. Although traditionally the fruit of the açaí palm was not part of the Parakanã's diet, today it is occasionally consumed.

Agriculture

In comparison with many other indigenous groups in Amazonia, the Parakanã practice a somewhat rudimentary agriculture. The relative lack of complexity in Parakanã agriculture may be the result of the loss of cultivars and agricultural knowledge following the social upheavals, migrations, and relocations that have happened over the past century or earlier (Chapter 4). Fausto (1997), for example, records a number of cultivars which were listed by elderly Parakanã and are no longer cultivated. A similar process of loss of agricultural knowledge is thought to have occurred in the past 200 years with the Awa-Guajá of Maranhao, who regressed from a horticultural society to strictly hunter-gatherers, subsisting mainly from the nuts of the babaçu palm and other wild foods. Balée (1993) suggests that this change resulted from their being driven from their ancestral lands and into areas occupied by enemy tribes. While the Parakanã did not reach this extreme, they do practice an inefficient form of manioc cultivation, practically abandoning a field after only one cropping cycle. As a result, in 1998 Paranowaona village ran out of manioc before the rice harvest came in. Other villages have also run out of manioc at times. The net effect of the inefficient process of manioc cultivation, along with the planting of commercial crops, has been the conversion of large areas of primary forest to secondary vegetation, and the exhaustion of suitable areas for agriculture in the proximity of the villages. In 1998, Paranatinga village was opening new fields at a distance of 2-4 km from the houses. The Parakanã cultivate few varieties of manioc, and these are processed strictly by the "wet" or *puba* method in which roots are left to soak and ferment in a stream for several days. This method does not permit the use of tapioca starch, an important by-product of the “dry” method of processing, which involves mechanical grating of the roots.

Although manioc meal is the preferred carbohydrate source, other staple crops, namely rice, beans and maize, consumed as sweet corn, have become increasingly important. These crops were introduced by FUNAI employees, along with the agricultural planting practices. A recent technology adoption has been the *feijão abafado* method, in which cowpeas or beans are planted in slashed secondary growth, similar to the *frijol tapado* of Central America (Bellows, 1992). Agricultural fields are either monocultural plantings, or intercrops of maize and manioc, and more recently, rice and manioc. Banana plants may also be scattered throughout manioc fields. There is no specific utilization of microsites for more nutrient-demanding crops such as banana, as is the practice among the Waimiri-Atroari (Miller, 1994) or other tribes (Posey, 1985).

Fields may be planted communally, by the entire village, or by extended family groups corresponding to political subdivisions within a village. Villages have two or more of these groups. Individuals may also plant smaller fields, generally less than 0.5 ha, on their own initiative. In 1998, the area cleared and planted by each of the villages ranged from 6 to 35 ha, with an average of 18.4 ha. The largest single field, with 14.5 ha, consisted of a communal planting of rice and maize at Paranowaona village. In 1999, the area cleared and planted by villages ranged from 6.5 to 14 ha, with an average of 10.4 ha. Again, the largest single field, of 8.2 ha, was at Paranowaona village.

Cultivation of fruit trees around houses or villages appears to be a relatively new practice for the Parakanã. Although at Paranatinga a number of fruit trees were planted around the FUNAI post by employees in the 1980s, this practice had not been replicated around the village. At the newly established Paranawaona village, however, numerous seedlings of fruit trees were planted around the houses, a result of the efforts of a FUNAI employee. Together with the Parakanã, he raised and planted 200 mango seedlings, 120 cashew seedlings, as well as a smaller number of jackfruit, cupuaçu, and papaya seedlings.

The principal agricultural products cultivated for commercial purposes by the Parakanã are rice, maize, bananas, beans and chickens. Although chickens are relatively minor contributors to income for most villages, they are important because they can be sold at any time of year, when agricultural crops or forest products are unavailable. A chicken may be sold from anywhere between R$ 3-5, depending upon its size. The contribution of the different agricultural and extractive forest products to the Parakanã economy are presented in figures on the following pages (Figs. 5-1, 5-2 and 5-3). Details on the harvesting and marketing of extractive forest products are discussed in the following section.

Extractivism

The Parakanã Indians obtain cash income from gathering and selling forest products such as Brazil nuts, cupuaçu fruit, açaí palm fruits and the honey of native stingless bees. These items are discussed separately below.

Açaí: The multi-stemmed açaí palm grows in dense stands along perennial streams. A single clump contains several individual trunks which may each bear two or three bunches of fruit. A large fruit bunch may contain several hundred small fruit, which are

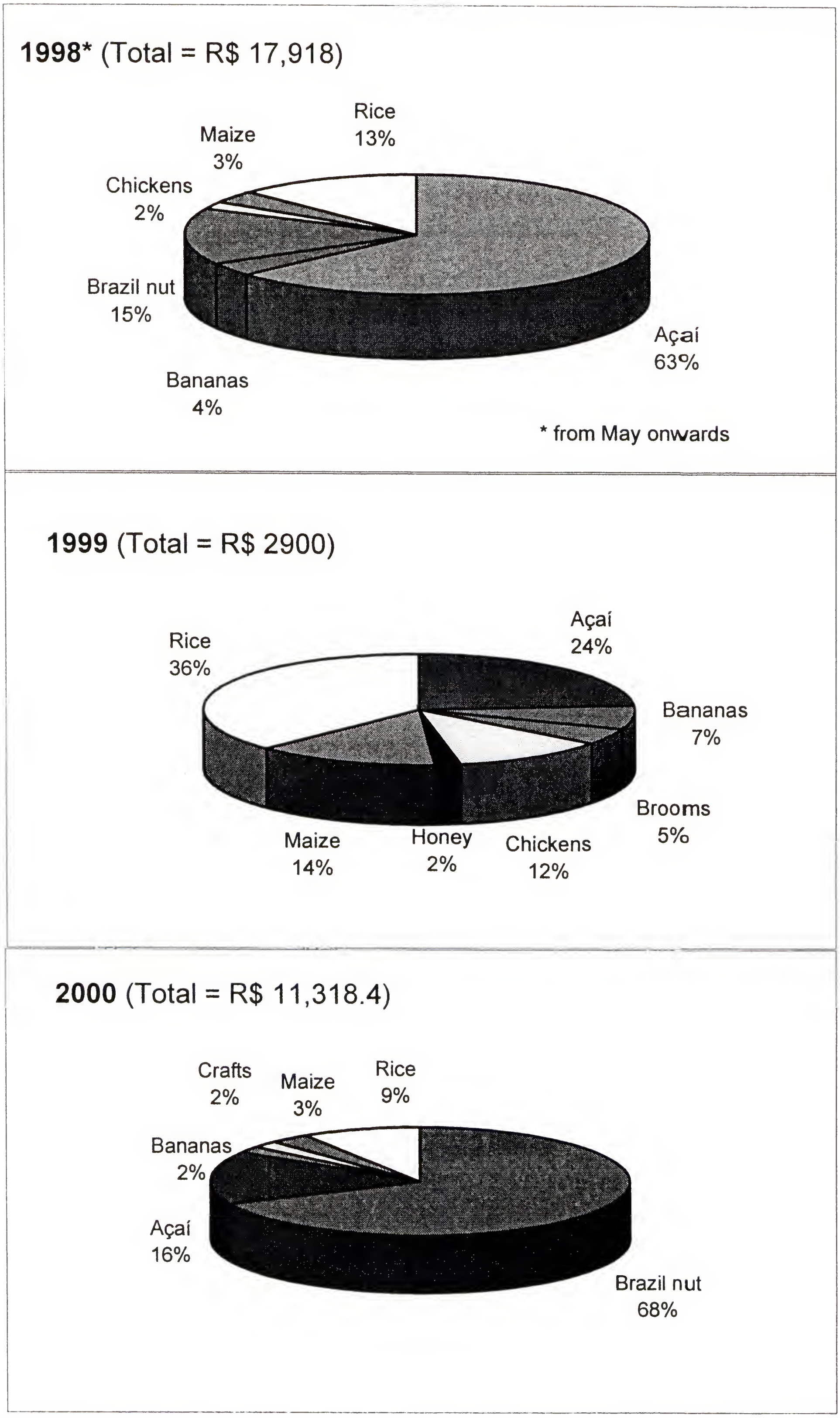
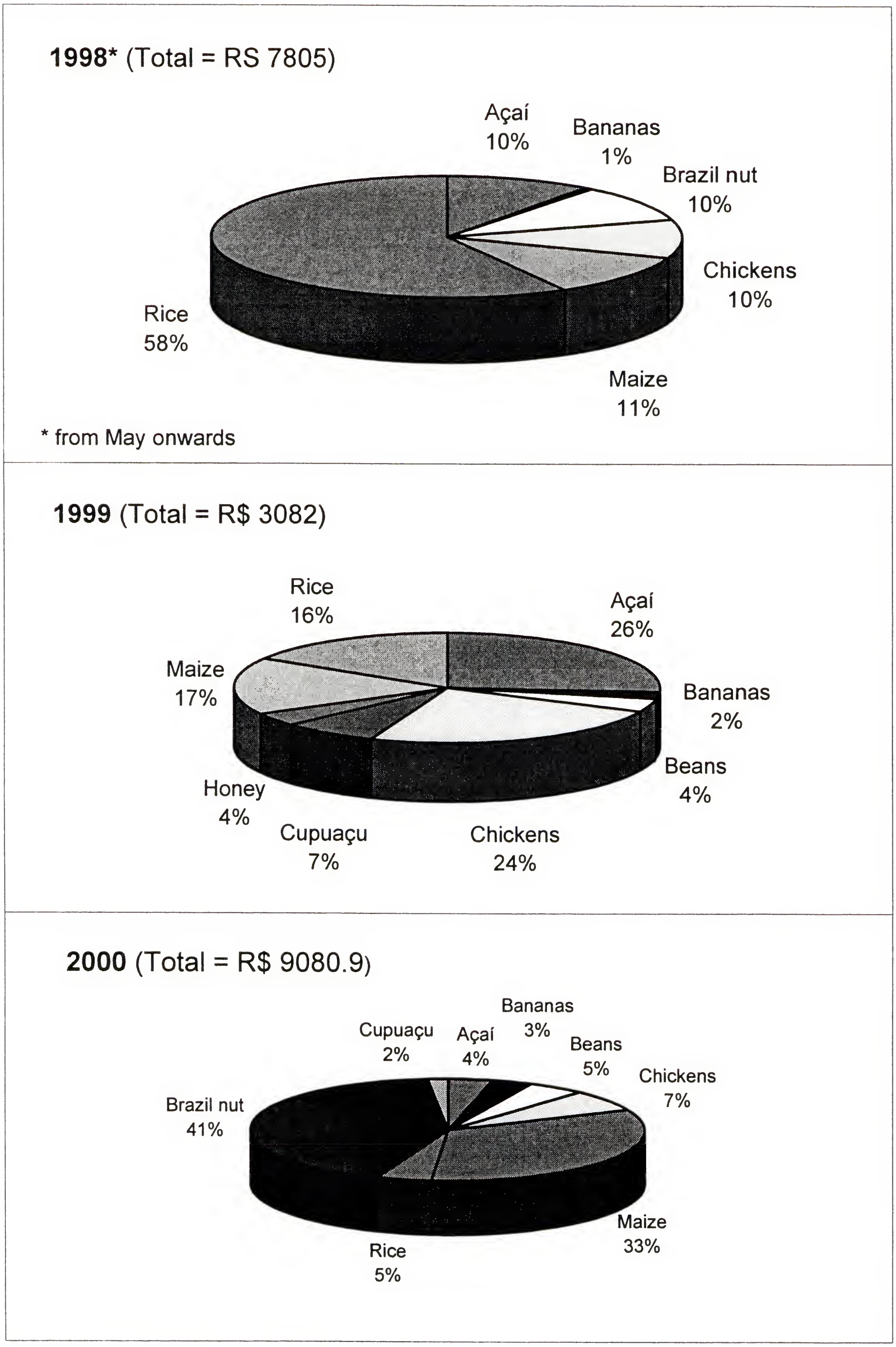


Figure 5-1: Extractive and agricultural products contributing to income for Paranatinga village, Parakanã Reserve, Pará



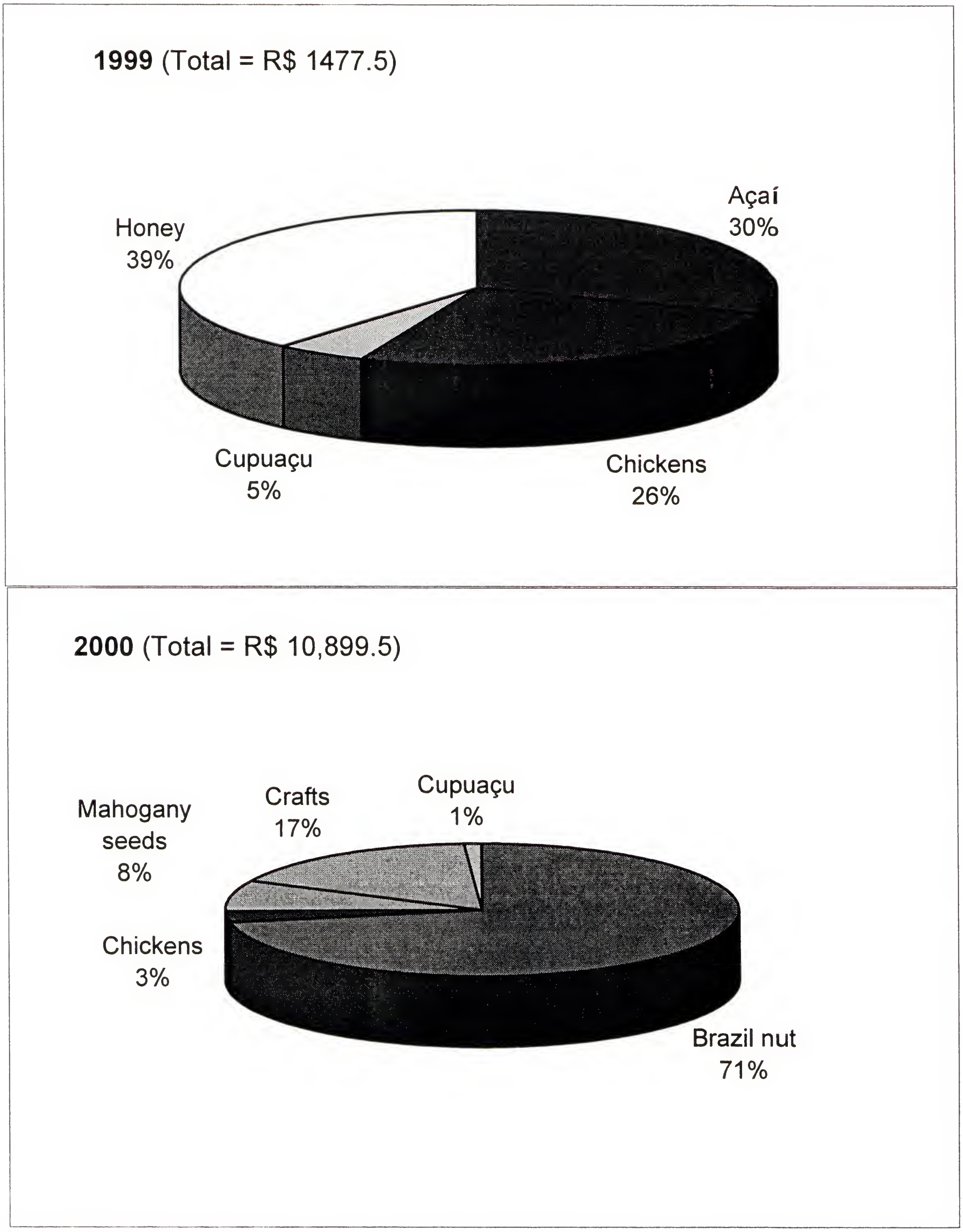
1998* (Total = RS 7805)

* from May onwards

1999 (Total = R$ 3082)

2000 (Total = R$ 9080.9)

Figure 5-2: Extractive and agricultural products contributing to income for Paranowaona village, Parakanã Reserve, Pará



1999 (Total = R$ 1477.5)

2000 (Total = R$ 10,899.5)

Figure 5-3: Extractive and agricultural products contributing to income for Maroxewara village, Parakanã Reserve, Pará

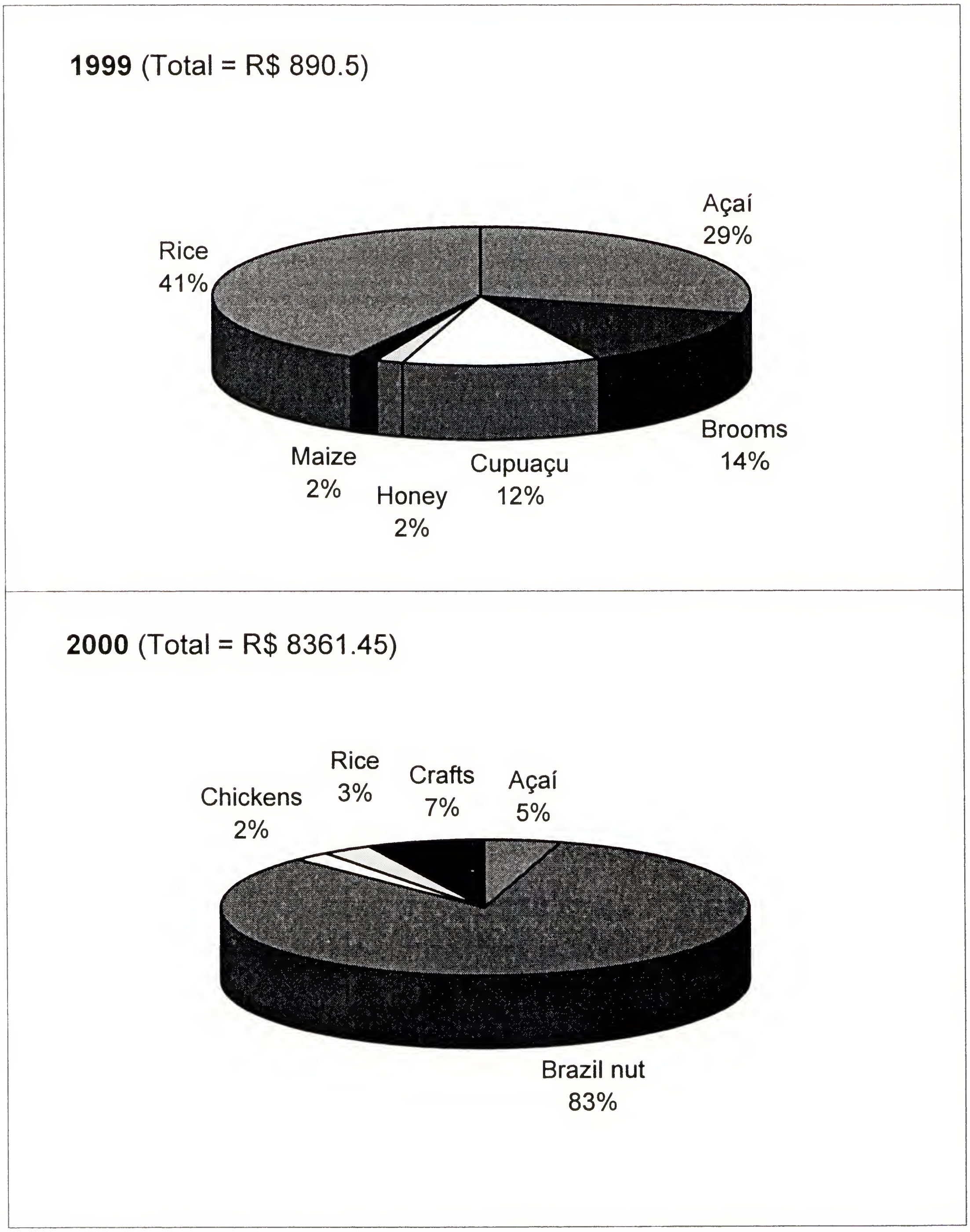


Figure 5-4: Extractive and agricultural products contributing to income for Itaygo'a village, Parakanã Reserve, Pará

composed of a large seed, slightly larger than a pea, covered by a thin mesocarp and husk. A thick nutritious drink, known locally as *vinho de açaí*, is made by softening the fruit in warm water, beating with a pestle (often a bottle) to remove the husk and pulp, then adding water and straining out the bits of husks. The *vinho de açaí* traditionally was an important daily dish for the residents of Belém and the estuarine region of Pará, sweetened and consumed with manioc or tapioca meal. In 1995, total production of açaí in Brazil was 108,922 tons, of which Pará was responsible for 94% (IBGE, 1998). The açaí which grows in the Parakanã Reserve begins to ripen in January, and its season extends through June, coinciding with the period of lowered production for the açaí stands which grow in the estuarine region. These stands near Belém have their peak production from August/September to January/February (Siqueira, et al. 1993). In the Parakanã Reserve, most of the açaí is harvested by Paranatinga and Itaygo'a villages from stands growing near the Transamazon Highway. These two villages share four semi-permanent camps along the 36 km stretch of highway which forms the eastern boundary of the Reserve. Family groups may stay overnight at their camps in order to harvest the fruit in the early morning. Most fruit are gathered within 500 m of the highway, but some may be gathered from a distance of up to 2 km. Gathering is done by climbing the thin trunks with the help of a *peconha*, a young açaí leaf twisted into a loop and placed around the ankles in order to increase the grip of the feet. Both men and women, as well as older children, do the climbing. The fruit are stripped from the bunches and placed in large baskets woven from the roots of an epiphytic aroid (*Heteropsis* sp.), lined with the broad leaves of understory herbs in the Heliconia family. The baskets are carried with the aid of a tump strap and taken to locations near the highway. As açaí is quite perishable, previous arrangements will have been made by radio with the Program office in Tucuruí to contact buyers. These buyers are owners of small shops which process the *vinho de açaí* and sell it to consumers in one or two liter bags. The Program truck will leave Paranatinga village early in the morning and pass by the camps to pick up the baskets of açaí and transport them to the city. In 1998, alternative arrangements were made with a buyer who purchased large quantities of açaí to transport to Belém. This buyer would meet the Program truck at the entrance to Paranatinga village, on the Transamazon, and pack the açaí in plastic bags on ice. This arrangement was not possible in 1999, as the rainy season extended well into June, making transit on that section of the Transamazon difficult for vehicles not equipped with four-wheel drive. The unit of measure for açaí is the 18 liter can, which was sold for R$ 5 in 1998, and for R$ 8 in June 1999. In January 2000, açaí taken to Tucuruí was sold for R$ 6 per 18 liters. However, this coincided with the availability of açaí from Cametá, and buyers were more choosy about the quality of the açaí. At such times when supply is plentiful, quantities of açaí brought from the Reserve cannot easily be sold unless previous arrangements have been made, as the shop owners often commit to purchase from local suppliers a day or two in advance.

Although the Parakanã do not harvest açaí palm hearts, a number of their neighbors have cut their stands to supply the growing demand for this product. Small processing plants for preserving palm hearts exist in the towns of Novo Repartimento, Cajazeiras and in the city of Marabá. In May 1999, prices paid to farmers for palm hearts were R$ 50/thousand if the buyer did the harvesting, and R$ 100 if the landowner harvested the palm hearts and delivered them to the roadside. A range of perceptions concerning the açaí palm were observed among the Parakanã's neighbors. Many farmers had allowed palm heart buyers to clearcut their stands. This was often the case of farmers in need of money, or ranchers who had no particular interest in consuming or selling the fruit. However, one informant commented that clearcutting results in a stand which grows back at an even, low height, making future fruit harvesting easier. His family had sold their açaí for palm hearts, but he said that their interest in the future would be in the sale of the fruits. Another informant reported that it is advantageous to selectively cut only the taller palms, which are more difficult and dangerous to climb when harvesting fruit. This is currently the system employed in the estuary region near Belém, where there is a strong demand for both palm hearts and açaí fruit. However, this system generally requires management or thinning of the other trees to reduce shading of younger palms (Anderson, 1990). Another perception was expressed by a local resident hired to teach the Parakanã the art of making dug-out canoes. On his property he favored the preservation of all açaí palms, and harvested the fruit of the shorter palms, leaving the fruit of taller palms to be taken by game birds, or once fallen, to be consumed by animals such as armadillos and tortoises. While consumption of açaí is a strong tradition in parts of Pará, many colonists are newcomers to the state, and do not have a taste for açaí. This undoubtedly influences their decisions on how to manage the açaí stands on their property.

Brazil nut: The Brazil nut tree (*Bertholletia excelsa*) is a canopy emergent, and is one of the largest trees of the Amazon forest, reaching a height of 50m and a diameter of 2m. Around 15 nuts are encased in a hard spherical husk, which can weigh more than 1 kg.

There may be very considerable year-to-year variation in nut production. In the 1998-99 season in southern Pará, for example, there was virtually no crop. The following year, however, produced a bumper crop. This bumper crop in the 1999-2000 season apparently occurred all across Amazonia, from Pará to Acre.

The Brazil nut began to assume commercial importance around 1850-1860. By 1920, production fluctuated between 20,000 to 30,000 tons per year, and today, production is around 30,000 to 40,000 tons/year, making Brazil nuts the second most important extractive forest product in Amazonia, following rubber (Emperaire and Mitja, 2000). Because they are protected by law, adult Brazil nut trees are left standing when forest is felled for agriculture or pastures. However, approximately half of these trees succumb when the felled forest is burned. And despite legal protection, sawmills will surreptitiously process the timber of Brazil nut trees.

The Parakanã have harvested Brazil nuts on a commercial basis for more than 20 years. According to Ferraz (1997), this began through the efforts of a FUNAI employee, who also sold bananas and game for the Parakanã in Tucuruí. In 1978, the sale of around 400 hectoliters was recorded, and in 1979, the quantity sold was 612 hectoliters. The Parakanã received their payments in the form of goods such as shotguns, clothes, flashlights, and batteries.

In the 1997-98 season, the nut harvest was organized by extended family groups. The hard capsules containing many nuts were gathered under the trees and carried to central locations near the village, where they were kept in low corrals made of logs. After a sufficient quantity accumulated, the fruits were cut open with a machete and the nuts were put into sacks. In 1999-2000, perhaps due to the bumper crop, capsules were cut open in the vicinity of the trees, and harvesting appeared to be more of an individual or nuclear family initiative. Access to Brazil nut trees can be by forest trails, road or river. In Maroxewara village, where nut harvesting was accompanied closely, all three means of access were used. Distances of at least 5 km were traveled on forest trails to get to Brazil nut trees. After a sufficient quantity had been accumulated, the sacks of nuts were transported to the village on mules. It is possible that other villages that do not have mules do not penetrate this far into the forest to harvest nuts. The 16 km access road from Maroxewara village to the reserve boundary was also used as starting point for nut harvesting. Nuts were brought to the edge of the road for later transport by four-wheel drive vehicle. Distances of up to 7 km (one-way) were traveled on foot along the road during one day outings to gather Brazil nuts. This appears to be near the limit regarded as practical for a single day's outing, as at 11 km from the village a camp had been established for overnight stays while nut harvesting. A camp had also been set up down river from the village for harvesting nuts, with access by aluminum skiff equipped with an outboard motor. The sacks of nuts gathered along forest trails or along the river were brought to the village and stored in the houses until the time of transport to market. Sacks of nuts gathered along the road were stored on raised log platforms to minimize loss to agoutis, a large forest rodent (*Dasyprocta* spp.). Members of Paranatinga village, which is connected to the Transamazon Highway by an 8 km access road, set up camps just off the Transamazon as a base for nut harvesting. Nuts are stored at these camps until there is transportation to the village. These camps are semi-permanent, and are used at other times of year as a base for açaí harvesting and hunting excursions.

Negotiations for the sale of the Brazil nut crop are generally made by the manager of the Parakanã Program, who contacts several buyers in order to find the highest price. The nuts may be delivered to the buyer in the Program's seven-ton truck, or the buyer may pick up the nuts at the village. Village representatives accompany the sale and with the help of a teacher, keep track of each individual or group's contribution as the sacks are measured into a one hectoliter box, the standard measure for Brazil nuts. In 1998, the price per hectoliter was R$ 29, an improvement over previous years, when prices ranged from R$ 16 to R$ 21/hectoliter. However, smaller quantities sold to middlemen in Novo Repartimento were purchased for R$ 22/hectoliter. In 2000, the first sale arranged with a bulk purchaser in Marabá reached a high of R$ 43/hectoliter. Small quantities taken to a buyer in the small town of São Sebastião, shortly before the main sale, however, were sold for only R$ 30/hectoliter. The village of Inaxyganga, inaccessible by road during the rainy season, had great difficulty in transporting its Brazil nut crop as the rains were insufficient to raise the river to easily navigable levels. A rented boat took about three days to transport 100 sacks of nuts at a time to an access road. By the time Inaxyganga's nut cropwas finally transported, the price had dropped to R$ 15 per hectoliter. This village could easily have harvested more Brazil nuts, but was discouraged from doing so by employees of the Programa Parakanã, in light of the difficulties involved in transportation.

Cupuaçu: The cupuaçu (*Theobroma grandiflorum*), a relative of the cacao (*T. cacao*), is a small to medium-sized forest tree which occupies the lower canopy. It is relatively frequent in the high forests of southern Pará. The large fruit (12-25 cm long, 10-12 cm in diameter) consists of a hard shell containing a number of seeds surrounded by an aromatic, acid pulp, used in the region for juices, desserts and ice cream. Weight of the fruit averages 1.2 kg, of which 38.5% is pulp (Venturieri, 1993). The fruit are only ripe when they fall from the tree, at which time they are collected by men who are out hunting. Women may accompany their husbands on such forays, to carry game as well as cupuaçu fruits. At the height of the season, individuals may make specific outings to areas with greater densities of cupuaçu trees. In 1998 the fruit were taken by individuals to the market in Novo Repartimento, where they were sold to middlemen, or alternatively, were sent to Tucuruí where the driver or another employee of the Program was responsible for selling them to a middleman at the local market. In this last case, the fruit collected by individuals were sent in a sacks labeled with their names, and this information was recorded when the fruit were sold. When cupuaçu fruit are sold by individuals in Novo Repartimento, price is based on fruit size. When many fruit are sold by the lot in Tucuruí, generally an average price is given. The fruit are perishable, and must be sold within 3-4 days after they fall from the tree. Cupuaçu prices vary, being highest at the beginning and end of the season. Depending on the size of the fruit, the Parakanã receive anywhere between R$ 0.30 to R$ 1.00 per fruit. In the 1999-2000 season, cupuaçu sent to Tucuruí were sold very briskly out of the Program's craft shop for R$ 0.50 apiece.

The cupuaçu season is from October to June, with a peak from November to April (Muller and Carvalho, 1997). As was the case for Brazil nuts, production from wild trees was nil in the 1998-1999 rainy season.

Honey: The Parakanã harvest the honey of several species of stingless native bees (most likely *Meliponna* and *Trigona* spp.) by cutting down the trees in which these make their hives. The honey is placed in one liter bottles for sale, at the price of R$ 10/liter. Most honey is gathered at the end of the dry season and beginning of the rainy season, probably due to the greater number of forest trees flowering in the dry season (Alencar, 1997). However, in 1999 honey production was extremely low, and none was sold. The Parakanã reported locating hives which had no honey.

Other Products: Although some crafts are made for sale, they represent a minor portion of the Parakanã's total commercial transactions. These crafts include ceramics, bracelets, necklaces, baskets, fiber hammocks, bows, and arrows, and are sold in a small store at the Programa Parakanã office in Tucuruí. Some other minor products which are also sold are green coconuts, pineapples, and brooms made of split aroid roots.

A product which may become of increasing importance is the seeds of timber trees. Reforestation projects have increased the demand for such seeds, and in the case of mahogany, at least, adult trees are quite rare in the region now, outside of the Parakanã reserve. The Parakanã Program is stimulating seed collecting, and with the help of researchers from the Museu Goeldi and Embrapa in Belém, has conducted a course on the subject for teachers and community members. Collection of mahogany seeds was begun in 1999, but the greater part was lost due to inadequate storage methods. In 2000, however, members of Maroxewara village collected 18 kg of mahogany seed, which were sold for R$ 50/kg. Lesser quantities of tatajuba (*Bagassa guianensis*) seeds were also collected and sold.

Consumption

Cash income from the sale of agricultural and extractive products is used in the purchase of a number of different items. For the three villages closest to the Transamazon, purchases are made individually on trips to the town of Novo Repartimento. The goods purchased include food items such as sugar, coffee, crackers, biscuits, and bread. Snacks such as sodas, cake, and ice cream are purchased and consumed while in town. Manufactured items include shoes, clothing, soap, daypacks, sunglasses, radio/cassette tape players, cassette tapes, cigarettes, bicycles, stoves, and shotguns, with the more expensive items being purchased following the sale of the Brazil nut harvest. After the Brazil nut harvest in 2000, some leaders and individuals opened savings accounts in Tucuruí to deposit surplus income. However, before six months had gone by, all but two had spent these savings.

Besides purchases made with the income from agricultural and extractive products, another important source of goods in the Parakanã economy is the "Fund for Economic Equilibrium", which is a payment of R$ 500 made to each village every month. Every two months, village leaders travel to Tucuruí with a list of items to be purchased for their villages. Purchases are made in bulk when possible. Based on the receipts filed in 1997 and 1998, the principal purchases consisted of ammunition, coffee, sugar, cooking oil, salt, flashlight batteries and assorted tools, utensils, and supplies.

Tools and supplies such as machetes, hoes, and seed used in agricultural activities are purchased by the Programa Parakanã as part of its goal of stimulating agricultural production.

Ranking of Products by Economic Importance and Labor Requirement

In order to gain a better understanding of how the Parakanã perceive the relative costs and benefits of different agricultural and extractive products, a ranking exercise was carried out in four of the five villages. The results of this exercise are given in Tables 5-1, 5-2 and 5-3. Overall, Brazil nuts are regarded as one of the most lucrative products, and were ranked either first or second in terms of value by members of the different villages. However, despite the fact that the nuts are produced at no cost by the forest, a considerable amount of effort is expended in harvesting them, so that their labor requirement is similar to that of agricultural crops such as rice or maize. Açaí occupies a similar position, with high value, but equally high labor requirements. Cupuaçu, while presenting a low labor requirement, does not rank high in economic importance. It would be interesting to compare the Parakanã's perception of cupuaçu to that of the Gavião-Partekeje Indians of the Mãe Maria Reserve, near Marabá. According to their leader Konkrenu (pers. com. 1998), his community gathered and sold R$ 15,000 of cupuaçu in a two week period. However, the Gavião reserve is crossed by a paved highway, and located near a fruit pulp processing facility which is able to absorb all of their production, which is not the case for the Parakanã.

Although chickens were ranked low in economic importance (generally between fifth and eighth, except in the case of Maroxewara), it was pointed out that they are a reliable

TABLE 5-1: Ranking of (a) the relative economic importance of different extractive and agricultural products and (b) the amount of effort involved in their cultivation and/or harvesting; by members of Paranowaona village.

(a) Economic importance of products:

Rank	Adult men	Adult women	Adolescent males
1	Brazil nut = Rice	Brazil nut	Brazil nut
2	Açaí	Açaí	Rice
3	Maize	Rice	Maize
4	Honey	Maize	Açaí
5	Cupuaçu = Bananas	Chickens	Chickens
6	Chickens	Cupuaçu	Bananas
7		Bananas	Cupuaçu = Honey
8		Honey	

(b) Effort involved in harvesting products:

Rank	Adult men	Adult women	Adolescent males
1	Rice = Brazil nut	Açaí	Brazil nut
2	Maize =Bananas	Brazil nut	Açaí
3	Açaí	Rice	Rice
4	Honey	Cupuaçu	Maize
5	Chickens	Maize	Honey
6	Cupuaçu	Bananas	Cupuaçu
7		Honey = Chickens	Bananas
8			Chickens

TABLE 5-2: Ranking of (a) the relative economic importance of different extractive and agricultural products and (b) the amount of effort involved in their cultivation and/or harvesting; by members of Itaygo'a village.

(a) Economic importance of products:

Rank	Adult men	Adult women	Younger males
1	Brazil nut	Brazil nut	Brazil nut
2	Rice	Açaí	Rice
3	Maize	Rice	Maize
4	Açaí	Maize	Açaí
5	Chickens	Banana	Chickens
6	Bananas	Chickens	Bananas
7	Cupuaçu = Honey	Honey	Cupuaçu = Honey
8		Cupuaçu	

(b) Effort involved in harvesting products:

Rank	Adult men	Adult women	Younger males
1	Rice	Rice	Brazil nut
2	Maize	Brazil nut	Rice = Maize
3	Brazil nut	Açaí	Açaí
4	Açaí	Maize	Honey
5	Banana	Banana	Cupuaçu
6	Honey	Cupuaçu	Bananas
7	Cupuaçu	*	Chickens
8	Chickens	*	

* Chickens and honey are regarded as strictly men's products

TABLE 5-3: Ranking of (a) the relative economic importance of different extractive and agricultural products and (b) the amount of effort involved in their cultivation and/or harvesting; by adult males of Maroxewara and Inaxyanga villages.

(a) Economic importance of products:

Rank	Adult men - Maroxewara	Adult men - Inaxyanga
1	Brazil nut	Maize
2	Honey	Brazil nut
3	Chicken	Honey
4	Cupuaçu	Açaí
5	Açaí	Chickens
6	*	Rice
7		Cupuaçu
8		Bananas

(b) Effort involved in harvesting products:

Rank	Adult men - Maroxewara	Adult men - Inaxyanga
1	Brazil nut	Maize
2	Honey	Brazil nut
3	Açaí	Rice
4	Cupuaçu	Cupuaçu
5	Chickens	Bananas
6	*	Açaí
7		Chickens
8		Honey

* Maroxewara village had not sold maize, rice or bananas in the recent past.

source of income all year around. This is not the case for the other products, which are of a seasonal nature. It is interesting to note that raising chickens is strictly a male activity. Although woven palm leaf nests are prepared for the hens, otherwise chickens are left to fend for themselves, to be collected on days when men are going to the market in a town. This division of ownership stands in sharp contrast to that observed in rubber tapper households in Acre, where cattle husbandry (and profits) are strictly a male realm, while decisions about the use of income from chickens are made jointly by the husband and wife (Nobre, 1998). In the rubber tappers' case, the care of chickens is a strictly female task.

Bananas are ranked rather low, generally near cupuaçu both in terms of economic importance and labor requirements. This may reflect the level of attention given to banana cultivation, which resembles more of an extractive than agricultural activity. Once banana plants are interspersed with other crops in the fields, little attention is given to them, in terms of weeding or thinning the mats for the production of larger bunches. This lack of attention to bananas may go beyond a simple lack of time to devote labor to this crop, and may in fact reflect cultural prejudices. According to Fausto (1997) the Parakanã traditionally regarded bananas as a "weakening" food.

In general, a product's ranking in terms of economic importance was roughly in equilibrium with its ranking for labor requirement, indicating that the Parakanã's choices of economic activities are made on a rational basis. This mix or economic choice of activities would most likely be different for non-Indian settlers in the region, given that the extractive activities combine well with the Parakanã's traditional activities of hunting and gathering, and their extensive land base. In the case of honey, for example, although ranked low in labor requirement, villagers reported that they had to go a considerable distance to find the hives.

Discussion

A comparison of the agricultural and extractive production in the different villages shows a diversity of strategies in the allocation of time and labor. These strategies clearly reflect not only the local availability of natural resources, but also access to transportation. The villages of Paranatinga and Itaygo'a, for example, are located in a region rich in açaí stands with reasonable access to the Transamazon Highway. More distant villages place a greater emphasis on non-perishable products which can be stored until the dry season, when access roads become passable. Brazil nuts are somewhat of an exception, as they can be transported by boat when rivers rise in the rainy season, and do not lose quality if they get wet.

The production of forest fruits such as Brazil nuts and cupuaçu, as well as honey, may be subject to great year-to-year variation, creating serious cash-flow problems for households who depend on these extractive products for income. In the case of Paranatinga village in 1999, besides the dearth of these products, sales of açaí were affected by the prolonged rainy season which made the Transamazon Highway almost impassable. This caused a severe drop in that village's annual income. While Brazil nuts may have a role in small-holder economies is Southeastern Pará, this may be too marginal to be the only basis for forest conservation. The inconstancy of harvests may be a disincentive, and the extraction of forest products may compete with agricultural activities for limited family labor. In the case of Brazil nuts, harvesting occurred at a time when it was also necessary to weed the rice fields. For settlers in the region, undue attention to a forest product could jeopardize their investment in an agricultural crop. Nevertheless, a study with colonists in the Marabá region found that for poorer families, forest products contributed up to 58% of gross household income. However, for better-off families, this figure dropped to 10%, with income from crops and livestock taking on a much greater importance (Muchagata, 1997).

Despite these drawbacks, interest in planting some forest products may increase, even for farmers with access to forests. A farmer living close to the Reserve boundaries, for example, planted approximately 100 cupuaçu seedlings under the shade of adult banana trees in 1998. Although cupuaçu is frequent in the forested portions of his property, he reported problems with theft, and was anxious to have trees closer to his home. The bumper crop of Brazil nut in 2000 may also have an effect on settlers' perceptions of the value of the forest. According to a buyer, many settlers were collecting between 10 to15 sacks of nuts from the forested portions of their properties. This is roughly equivalent to 6 to 10 hectoliters, which at R$ 30 per hectoliter, represents an income of R$ 180 to R$ 300, which compares very favorably with the official monthly minimum wage of R$ 151. This may counterbalance the temptation for settlers to sell their Brazil nut trees to loggers. According to an employee of the Programa Parakanã, a neighbor had sold eight trees for R$ 10 each. Each tree, however, is capable of yielding R$ 30 of nuts in a good year.[8] However, since NTFPs are harvested from the unfenced back reaches of colonists' properties they are especially vulnerable to theft, and day by day patrolling of such areas to collect fruits such as Brazil nut and cupuaçu may be incompatible with the labor demands of the settler's other activities.

In the State of Amazonas, a study with 33 families of Cambeba and Cocama Indians living in the region of Tefé, found that in terms of monetary returns/kcal invested, the production of manioc flour was twelve times more efficient than Brazil nut gathering. This finding corroborated the community's tendency towards reducing or abandoning their Brazil nut harvesting activities (Pereira, 1992). However, it must be pointed out that the region in which the study took place has a relatively low density of Brazil nut trees (1-3 trees/ha) and a high population of gatherers (approximately six adults for every tree).

Although not operating under the same set of socioeconomic constraints as the settlers in the region, it is instructive to examine the Parakanã's reliance on annual crops as a source of income. Besides contributing to food security, these crops (principally maize and rice) are harvested in the dry season, a period when there is little cash flow from extractive products. It remains to be seen if the Parakanã will be willing to include perennial crops in their agricultural system, and whether these will be managed as extractive products or agricultural crops.

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[8] According to this employee, the bumper crop of Brazil nuts generated a considerable amount of theft and conflict between settlers. In his own case, when he went to harvest the nuts on his property while on leave, he found only the husks.

Conclusions

Within the context of regional development, the Parakanã example provides an extremely important counterpoint to the patterns of land use which have prevailed since the opening of the Transamazon Highway, namely, widespread deforestation for agriculture and cattle ranching. This contrast between a land use which destroys the forest and one which conserves the forest is perhaps nowhere as marked as at the limits of the Parakanã Reserve on the Transamazon Highway (Figs. 5-5 and 5-6). On one side of the highway, the forest has been left standing, providing tangible benefits of income and sustenance for a community, and intangible environmental services such as watershed protection, climate regulation, conservation of biodiversity, among others. On the other side of the highway can be seen occasional açaí palms, remnants of the groves which once occupied the low-lying areas around streams, and the silhouetted figures of dead Brazil-nut trees, in a sea of pasture being overtaken by babaçu palms and weeds.

The Parakanã example provides a very positive outlook for the economic potential of forest conservation and the marketing on non-timber products. However, this optimism must be tempered by considering that the Parakanã's economy is underwritten by an aid program which provides not only tools, transportation, and assistance in marketing, but also health assistance. This last item is not of little importance. In a region where malaria is rampant, productivity of agricultural and extractive activities can be greatly affected if timely and effective health care treatment is not available. Besides the effects of ill health, colonists also lose time and money when they leave their farms and travel to

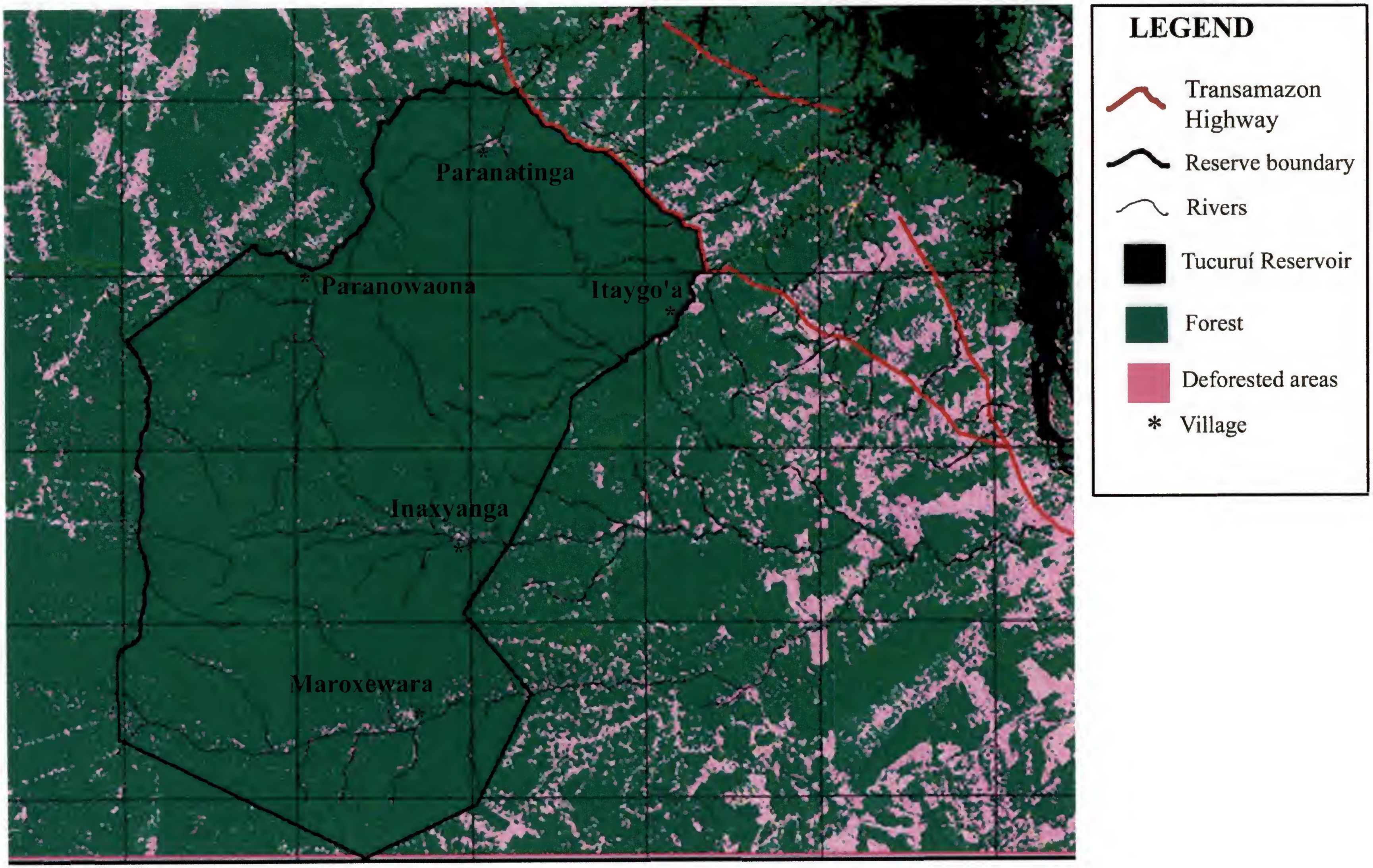

Figure 5-6: LANDSAT image of the Parakanã Indian Reserve, Pará, 1996, showing location of villages. Courtesy of ELETRONORTE - Superintendência de Meio Ambiente/Divisão de Planejamento e Estudos Ambientais.

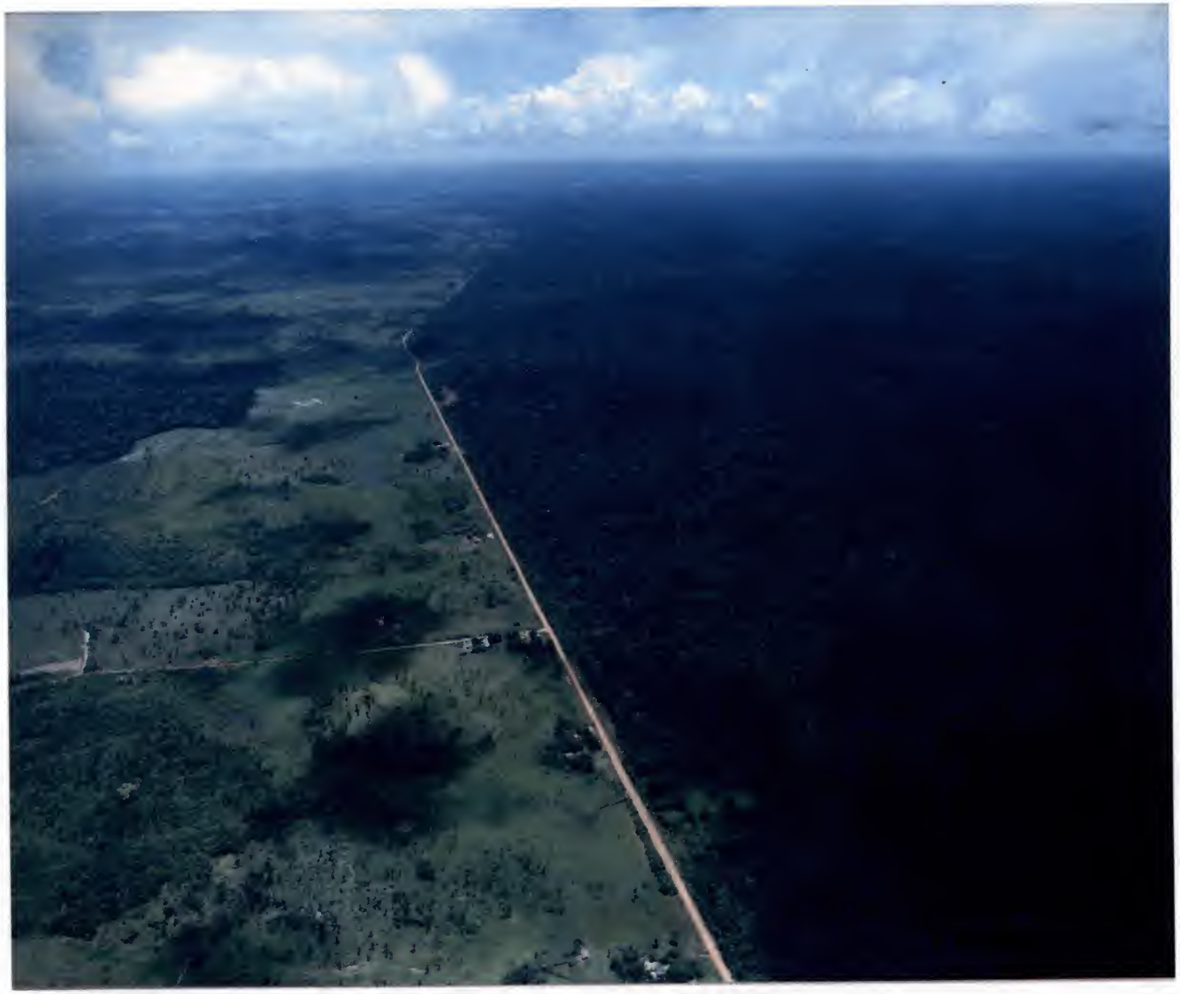

Figure 5-6: Aerial view towards the South of the Transamazon Highway, with the forested Parakanã Reserve on the right and pastures on the left. A side road running East can be seen coming off the highway. (Photograph courtesy of Eletronorte)

locations with health posts for treatment. Nevertheless, health considerations aside, the Parakanã community's relation to the regional economy is not unlike that of a cooperative whose members receive services such as the information necessary to assure sales at the best prices, the financing of certain factors of production, and the bulk transportation of goods to avoid middlemen.

The particular case of the Parakanã must also be considered in the light of the history of land use in the region surrounding them. The construction of the Transamazon Highway and a network of feeder roads, with its attendant deforestation, has meant that many forest products have become scarce and are now more difficult to access, for example açaí fruit and mahogany seeds. For the Parakanã villages near the Transamazon Highway, the combination of a large area of preserved forest and relatively easy access translates into a very positive potential for income. Perhaps one lesson to be learned from this is that the conservation of forests offers economic benefits that are not immediately visible, but could be of significant importance a few years hence. A decade ago, the idea that the Transamazon region would be supplying açaí to Belém would have appeared very unlikely. Changes in political climates leading to an increased preoccupation with forest management have now resulted in a demand for the seeds of timber trees, something practically nonexistent a few years ago. If the promises of politicians with regard to the paving of the Transamazon Highway are realized, the economic potential of different forest products could be further altered. While improved access to transportation may increase the marketability of certain perishable products such as cupuaçu and açaí, the increased value of these products may not be sufficient to guarantee conservation of the forest. Improved access will increase land prices, as well as transforming the dynamics of the use of timber species. Lower value species may suddenly become marketable if transportation costs are reduced by improved access, as has occurred in the Paragominas region, where loggers now routinely harvest dozens of tree species (Homma et al.,1998). The single example of the Parakanã's use of the forest may not be sufficient to convince landowners of the value of forest conservation, when the norm for the region is agricultural systems which have a high potential for the degradation of natural resources.

CHAPTER 6
FROM HOME GARDENS TO FIELDS: EARLY GROWTH OF FRUIT TREES IN PARAKANÃ VILLAGES AND FIELDS

Introduction

Fruit tree "home gardens" are traditional agroforestry systems found throughout the tropics (Nair, 1993). In Amazonia, the cultivation of fruit trees was a well-established practice before the arrival of Europeans, and may date to the very dawn of agriculture in the region (Lathrap, 1977). While the main role of fruit tree home gardens is their contribution to domestic food supplies, they may also contribute to household income, if fruit or other products are sold.

The ecological stability of home gardens and their potential for generating income has led researchers to suggest that their expansion could be the starting point for a more commercial agricultural development (Smith et al., 1996). However, home garden systems occupy a zone around dwellings characterized by significant inputs of nutrients, a result of the presence and activities of humans and domestic animals, and by the greater attention to the management and care of useful plants. For tree species that are more demanding of nutrients and light, the expansion of plantings beyond this zone may imply in the occupation of sub-optimal sites. This may be particularly true in regions with low fertility soils, as is the case for much of Amazonia. If farmers are to plant trees in their fields, a fundamental concern is the initial growth of trees in the first years after planting. Most slash-and-burn fields are abandoned after two or three crops, and secondary forest regeneration is rapid. If fruit trees are not well-established and of sufficient size to compete with pioneer vegetation by the time cropping is discontinued, farmers may find that it is not worthwhile to invest time in the periodic weeding and maintenance necessary for tree survival and fruit production. A qualitative assessment of the results of seedling distribution by PESACRE, an NGO in Acre, found that trees which did not grow quickly and compete reasonably well with fallow vegetation were abandoned by farmers (F.C. Nobre, pers. com., 1998). From the farmer's point of view, the viability of incorporating fruit trees into different cropping systems will depend greatly on the effect these systems have on the trees' survival and initial growth.

A better understanding of the biological and socioeconomic constraints to the expansion of home gardens will require several questions to be addressed. These include: (1) Are there tree species better adapted to these sub-optimal conditions?; (2) What are the costs of labor and fertilizer inputs required to assure the adequate performance of more demanding species?; and (3) Are these inputs viable given the socio-economic conditions of small-scale farmers in the region?

With the above questions in mind, an agroforestry pilot project was set up in two Parakanã villages in Pará, Brazil, under the auspices of the Programa Parakanã. Along with health, education, and protection of the reserve, one of the goals of this Program is the improvement of the Parakanã's economic relationship with surrounding society. In keeping with these goals, the agroforestry project looked at the viability of incorporating commercial fruit trees into the Parakanã's existing system of slash-and-burn agriculture. One of the principal objectives of this project, therefore, was to determine how different tree species would respond to varying field conditions. While the project was conducted within the specific reality of indigenous communities, it is hoped that its findings will provide useful information in a regional context for the establishment of agroforestry systems by small-scale farmers.

The details of the project and its results are discussed in the following sections.

Materials and Methods

Following a brief visit to the Parakanã reserve in September of 1997, the project was initiated in January of 1998 in the villages of Paranowaona and Paranatinga. Measurements of tree growth were completed in March 2000, two years after planting. Some additional measurements and collection of soil samples were carried out in September 2000.

Species

Four species of fruit trees were employed for experimental plantings in different environments. They were: coconut (*Cocos nucifera*), cashew (*Anacardium occidentale*), soursop (*Annona muricata*) and cupuaçu (*Theobroma grandiflorum*). These species were chosen to represent a range of ecological requirements in terms of light and nutrients, allowing a maximum spread in growth responses to the experimental conditions. Some of the principal characteristics of these species are given below:

- Cashew: light demanding from the seedling stage, but tolerant of poor soils, as long as they are not waterlogged. It is widely cultivated in homegardens. Some varieties begin fruiting less than two years after planting.

- Coconut: light and nutrient demanding from seedling stage. An exotic to the region, coconut is increasingly cultivated not only as a homegarden species, but also on a commercial scale.

- Cupuaçu: tolerant to acid soils with high Al levels. Low nutrient requirements. Requires shade during seedling phase, and may be grown under moderate shade as an adult tree. Cupuaçu is native to the forests of the region, where it grows as a lower canopy tree. It is widely cultivated in homegardens and there is an increasing amount of planting for commercial production.

- Soursop: a small to medium-sized tree bearing large fruit whose pulp is highly appreciated for juice and ice cream. In commercial plantations, it is generally cultivated under full sun, with moderate fertilization.

Seeds or seedlings were obtained from various sources:

- Cashew seeds were collected in the Waimiri-Atroari Reserve in Amazonas

- Coconut seedlings were purchased from a grower near Tucurui;

- Cupuaçu and soursop seedlings were obtained from the municipal nursery in Novo Repartimento.

Plot Layout and Experimental Design

In order to explore the constraints involved in the expansion of home gardens into field environments, seedlings were planted both around houses in the villages and in fields. Within the broad categories of village and field, however, some more specific environments were also identified and explored. In the field environments, for example, an additional line of inquiry concerned the effects of field microsites on tree growth. Slash-and-burn fields are extremely heterogeneous, with stumps, fallen logs, and varying amounts of ash, in accordance to the patchiness of fuels at the time when fields are burned. Such microsites are often explored in indigenous polycultures (Chapter 3) but their relevance to the growth of fruit trees in fields has not been established. Other environments considered in the study consisted of those created by different planting methods, such as fertilized or unfertilized planting pits, for coconut and soursop, and planting under the shade of banana or Brazil nut trees, in the case of cupuaçu. These environments will be explained in more detail in the following paragraphs.

Coconut and soursop seedlings were planted in the following environments: (1) polyculture fields of maize, manioc and banana; (2) bare earth yard around the houses in the village; and (3) bare earth yard with fertilized planting holes. In this last case, locally obtained materials (chicken manure, ashes and bones) were used as fertilizer. The characteristics of cupuaçu with regard to shade tolerance led to the choice of planting this species in two additional environments, besides fields and villages: (1) under the shade of banana plants and (2) under the shade of adult Brazil nut trees near the margins of fields. Planting cupuaçu under the shade of banana is being tested by the agricultural secretariat in Breu Branco (albeit with irrigation), and a colonist living next to the Parakanã Reserve has planted approximately 100 cupuaçu seedlings under banana. Planting cupuaçu under the shade of adult Brazil nut trees was not a part of the original research plan, but was an idea that arose from observations made in the Parakanã's fields. In their fields, Brazil nut trees may or may not be felled when the area is opened up for agriculture. As the area directly under the Brazil nut trees may be unsuitable for planting the usual crops due to excess shade or root competition, an alternative use would be to plant cupuaçu trees in these sites.[9] However, trees left standing are often killed when the field is burned. The mortality of Brazil nut trees can be reduced by leaving a protective band of vegetation at the time of felling, a practice which Pereira (1992) reports as being used by the Cocama Indians near Tefé, Amazonas. Although this practice is not employed by the Parakanã, the type of environment which would be created was found in several locations under large Brazil nut trees growing on the edges of fields. In these locations, the fires from burning fields (in Sept. 1997) had spread through the leaf litter into the nearby forest, killing a number of understory plants and saplings and increasing light penetration. Such a situation is similar to what would occur under Brazil nut trees left in a field and surrounded with a protective band of vegetation.

Plots for tree planting in fields were selected with the help of community members and were distributed among kin groups. In the three principal field plots, 5 m grids were staked out using a sighting compass and a 50 m tape. It was not anticipated that there would be any interaction between trees planted at a 5 m spacing, at least during the two-year period of the study. The grids and features such as stumps and logs were mapped on graph paper at a 1:1000 scale. These maps were later transferred to drafting paper and used to locate seedlings during monitoring. The layout of these plots is illustrated in Figs 6-1, 6-2, and 6-3. The one exception to this method for assigning planting sites was in a fourth field where cupuaçu seedlings were planted along a hunting trail running through the field. After mapping, wire flags of four different colors were distributed among the

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[9] The Parakanã reported that if a Brazil nut tree is left standing in a field, it will shed its leaves sometime after the field is burned, smothering young rice plants.

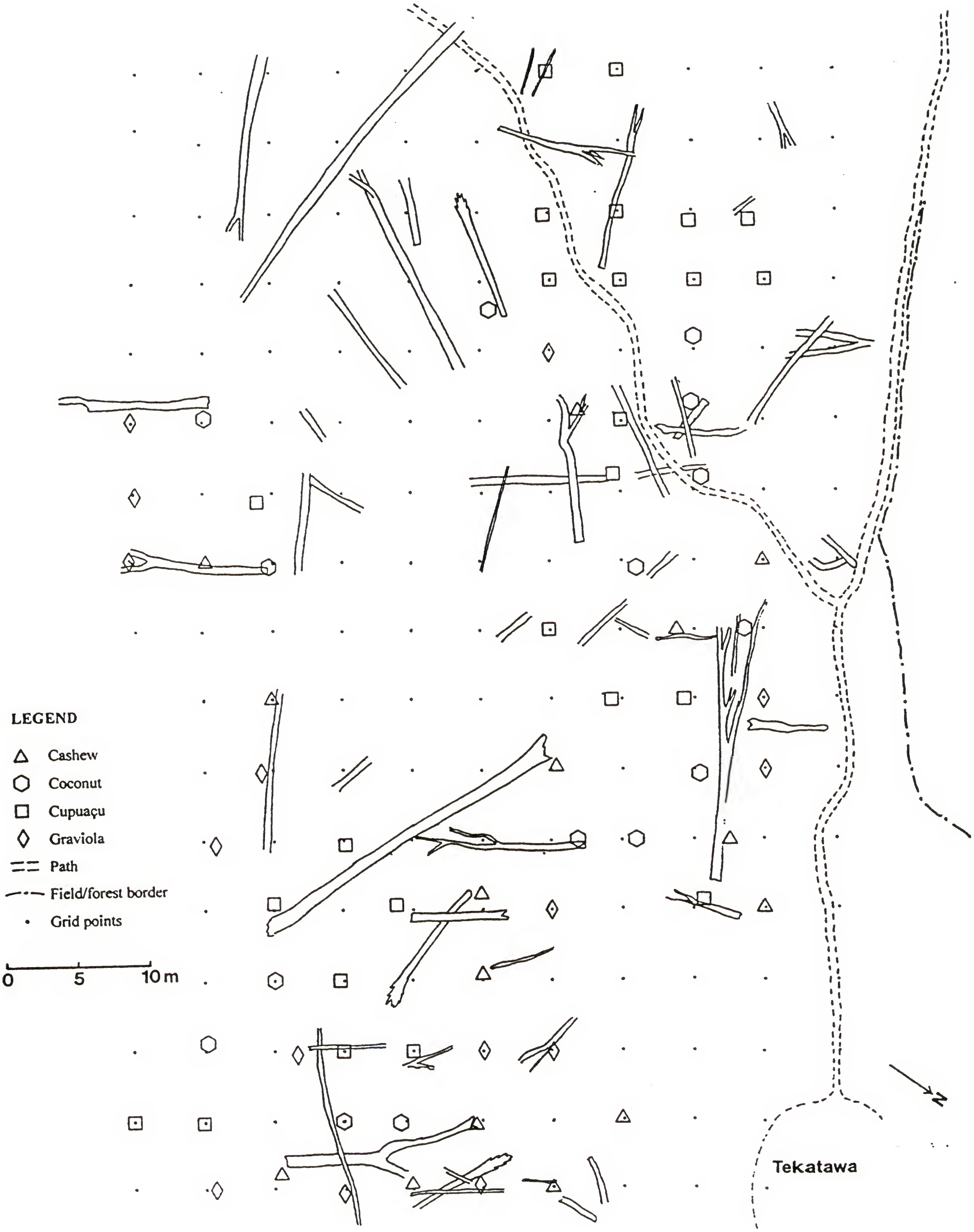


Figure 6-1: Map of fruit trees planted in Field 1 (Moxiapewa)

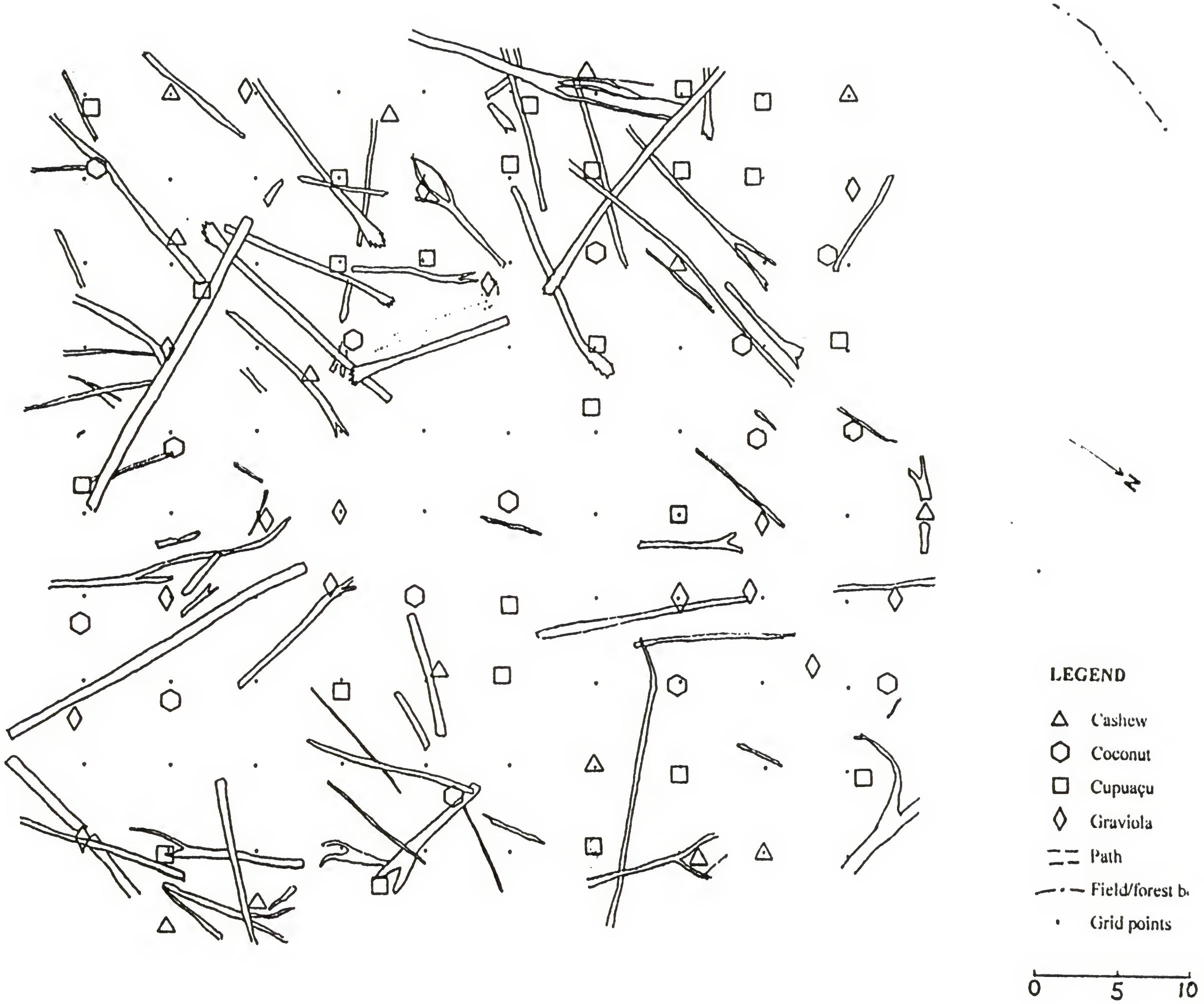


Figure 6-2: Map of fruit trees planted in Field 2 (Pikawa)

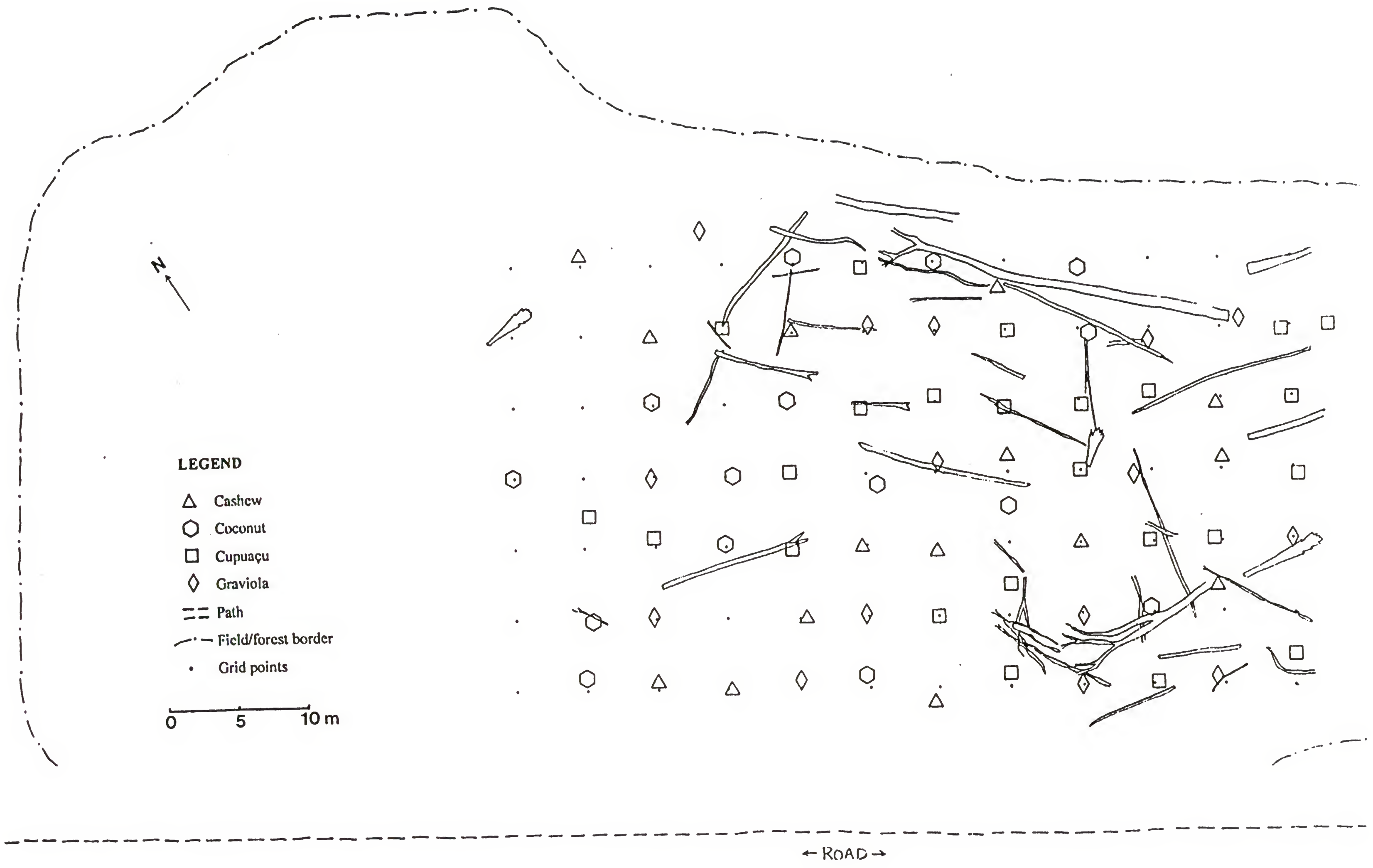


Figure 6-3: Map of fruit trees planted in Field 3 (Wararoa)

principal field microsites (ash concentrations, stumps, and neutral locations) to mark locations for planting seedlings. Microsites with ash concentrations were least frequent, so these were marked first, followed by microsites with stumps. In both cases, in order to find a suitable microsite it was sometimes necessary to locate the planting site away from a point on the grid. This distance was generally less than one meter, but sometimes more. Flags for neutral microsites, the most common, were distributed last. Once microsites were marked with flags, species were assigned randomly to each color. In each plot, a total of 15 seedlings of each species were planted, with 5 in each of the three microsites. In the case of cupuaçu, however, an additional 10 seedlings were planted in neutral microsites. At initial planting in fields, location of seeds and seedlings were marked with crossed sticks, an indigenous technique, in order to avoid their being cut or stepped on.

Cashew was direct sown for planting in the agricultural fields, a practice which is recommended in the literature (Garner and Chaudri, 1976). Two or three seeds were sown at each spot, and thinned if necessary following germination and seedling establishment. For planting in the village environment, cashew seedlings were raised in polyethylene bags in a small nursery and then distributed to community members (Fig 6-12 (b). Coconut was planted only as germinating seedlings. For cupuaçu planted under banana, seedlings were planted at a 4 to 5 m spacing in an irregular layout, approximately equidistant between banana plants, and their locations were marked with numbered hardwood stakes. For cupuaçu under Brazil nut trees, in two of the plots seedlings were planted on a 5 m grid perpendicular to a trail, while in the third plot seedlings were planted with the same layout used for planting under banana.

For planting around the village, seedlings were distributed to the male heads of household. The location of these seedlings was subsequently mapped and they were assigned numbers for future measurements (Figs. 6-4 and 6-5).

Measurements

Growth: Measurements of growth parameters (height, number of leaves or crown volume, for dicotyledons, and length of adult leaf and number of leaflets in the case of coconut) were made at intervals during a two year period. For cupuaçu, which has large leaves, it was possible to use leaf number as a growth parameter throughout the period of study. For cashew and soursop, however, it was not feasible to do leaf counts, so an estimate of crown volume was used as the growth parameter. Crown volume was calculated from measurements of total height, height to first branch, and two measurements of crown diameter, taken at right angles. A conical crown shape was assumed. Measurements were taken at approximately one month, five months, one year, and two years after planting. Competing vegetation in the immediate vicinity of the seedlings was slashed with a machete at these times. In September 2000 (2 ½ years after planting), additional measurements of stem diameter below the first branch were made on 117 cupuaçu trees.

Light: Prior to weeding around seedlings at each measurement, a visual estimate of overhead shade, on a scale of 0 to 5, was made. As visual estimates of canopy cover are regarded as "moderately accurate" (Vora, 1988), additional measurements of canopy cover were made with a spherical densiometer to verify the adequacy of visual methods. Each measurement made with the spherical densiometer consists of the average of four

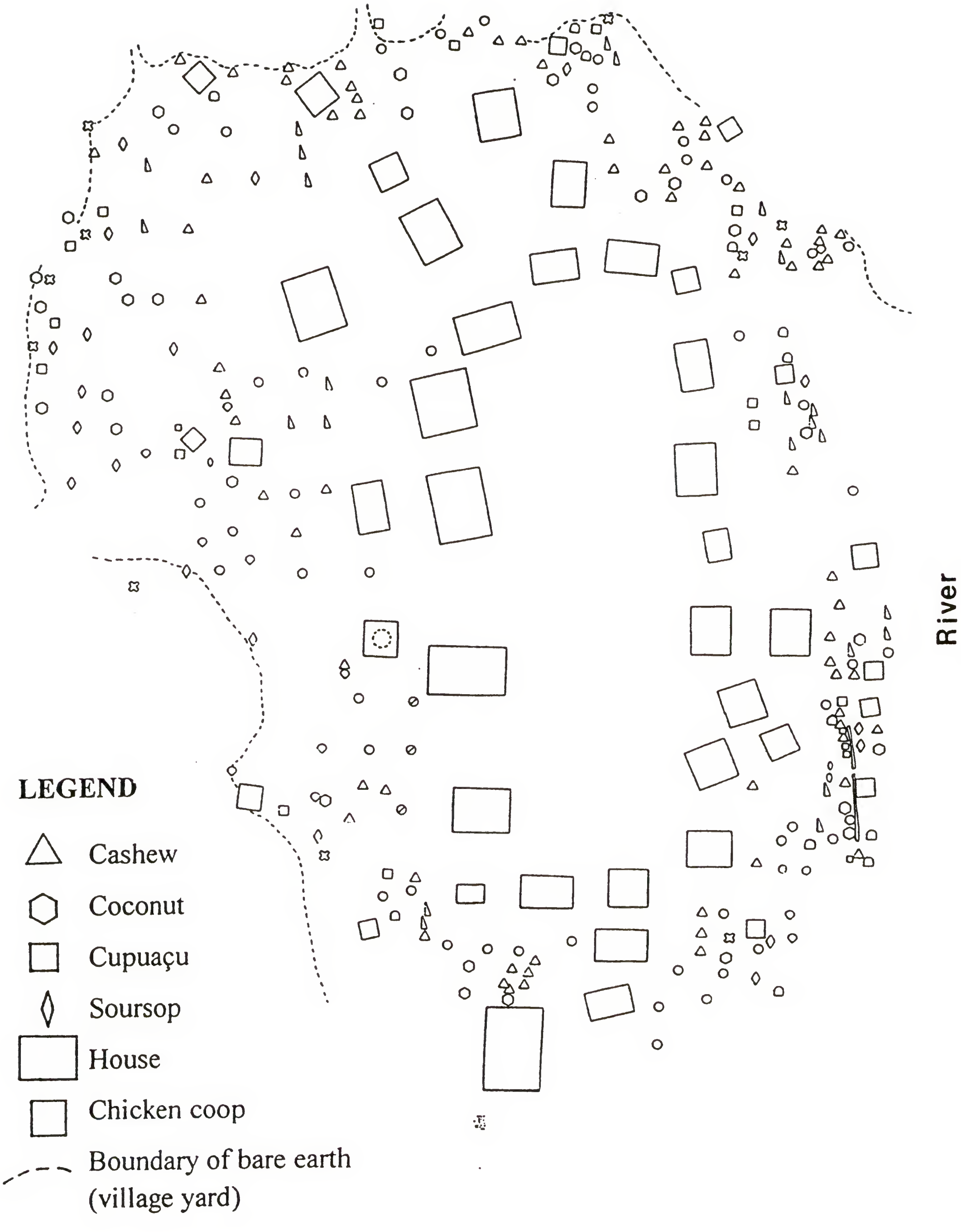


Figure 6-4: Location of fruit trees planted at Paranowaona village, Parakana Reserve, Pará

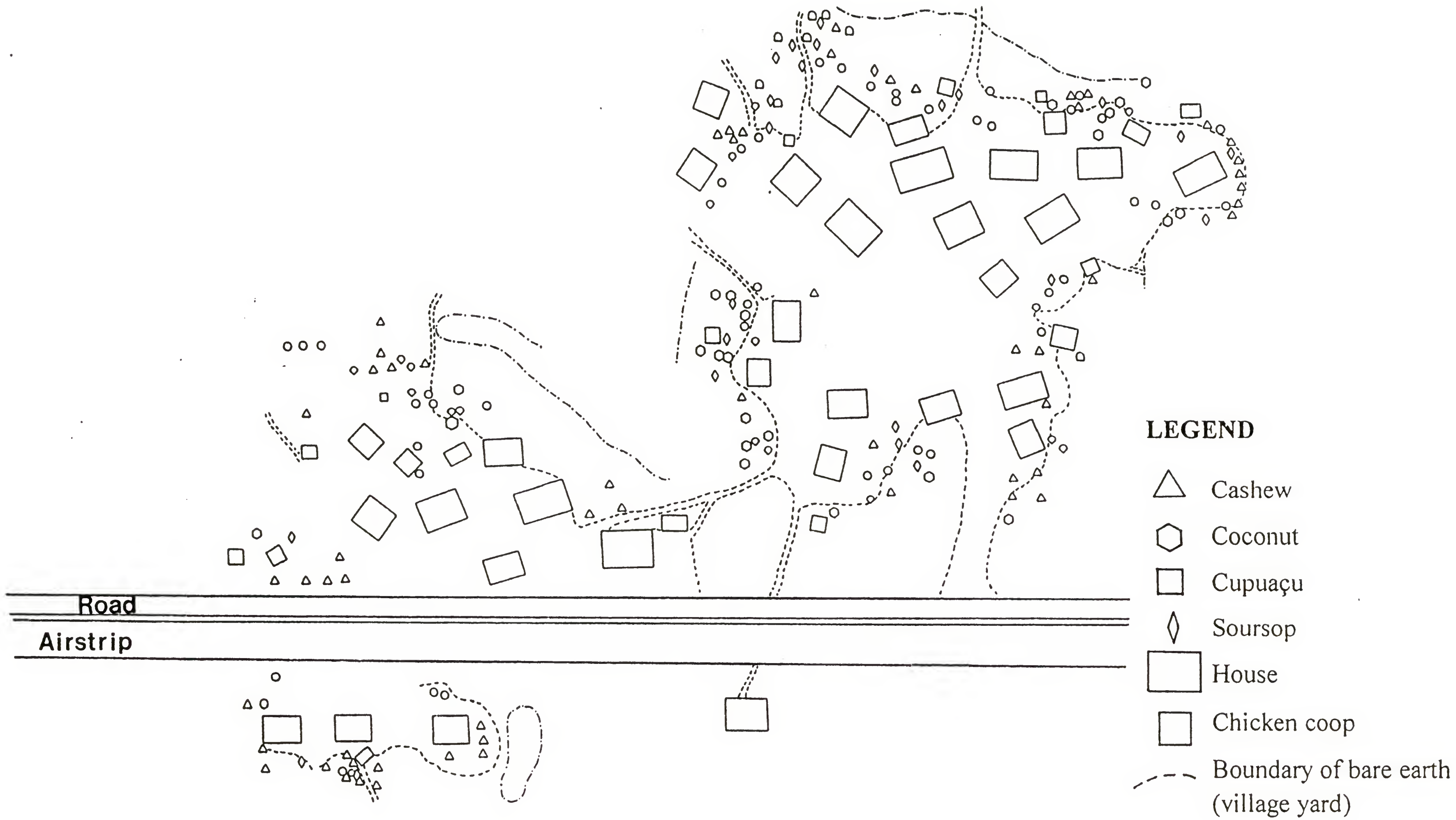


Figure 6-5: Location of fruit trees planted at Paranatinga village, Parakana Reserve, Pará

readings taken while facing the cardinal points, above (or next to) the seedling or young tree. The methodology and use of the spherical densiometer is discussed at length in Lemmon (1956), Vora (1988) and Bellow (2000). Densiometer measurements and visual estimates were made for 84 cupuaçu trees at 2 ½ years, along with diameter measurements. A regression analysis comparing these two methods shows a correlation of $R^2 = 0.63$ (Fig. 6-6). This correlation is only reasonably strong, and is less than the R^2 of 0.89 found by Bellow (2000) in a similar comparison of visual and densiometer estimates of canopy cover under tree plantations in Costa Rica. Bellow, however, points out that accuracy of estimates is dependent on the characteristics of the vegetation cover, with both visual and densiometer estimates showing less reliability when there is a mix of vegetation in different strata, as was the case in this study.

The scale used for visual estimates consisted of five shade classes, with the possibility of assigning intermediate half point values for situations judged to fall between these classes. These classes, along with their approximate canopy cover equivalent as derived from the regression with densiometer readings (Fig. 6-6), are as follows:

0: no shade (0% canopy cover)

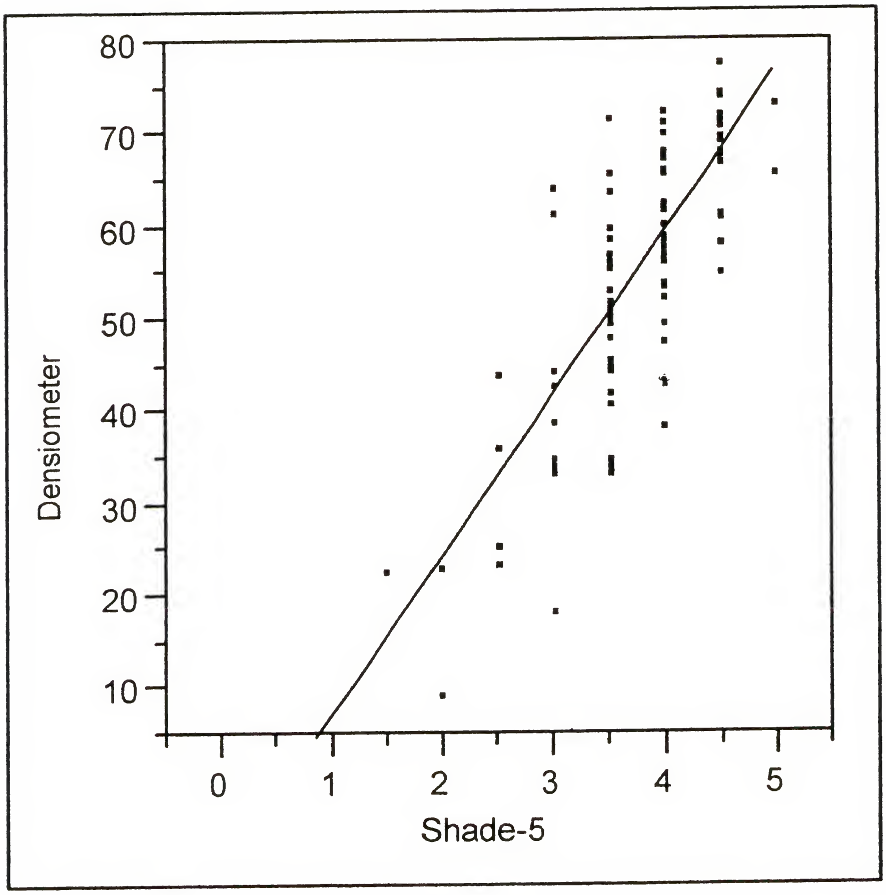
1: shade on one side, not directly overhead (<10% canopy cover)

2: shade on two sides, or light overhead shade (20% canopy cover)

3: shade on most sides, some overhead shade (40% canopy cover)

4: shade on all sides, patchy overhead shade (60% canopy cover)

5: full overhead shade (>80% canopy cover)



Linear Fit

Densiometer = -10.625 + 17.4202 Shade-5

Summary of Fit

RSquare	0.633125
RSquare Adj	0.628651
Root Mean Square Error	9.139587
Mean of Response	53.66333
Observations	84

Figure 6-6: Correlation of spherical densiometer measurements of canopy cover (in %) and visual shade estimates, on a scale of 0 to 5 (0 = no shade; 5 = full shade), in experimental agroforestry plantings, Parakanã Reserve, Pará.

For statistical comparisons of tree growth and shade levels, "shade" values represent the averages of the visual estimates made at each tree during the three monitoring periods. For the trees where canopy cover was measured with the densiometer, the additional visual estimates made at that time were included in these averages. Numerical data from the experimental plantings was analyzed with the JMP IN software by SAS Institute using standard statistical methods.

Fruit production: The percentage of fertile trees (flowering or fruiting) was evaluated for soursop and coconut. Due to the proximity of fruiting soursop trees to the village, and ensuing consumption by children, no attempt was made to measure fruit quantities or weights. Cupuaçu did not reach maturity during the period of study, so the vigor of the young trees was taken as an indicator of the potential for future performance.

Soil Samples

Soil samples were collected in the various plots to determine if these differed in terms of fertility and the effect of this on the results for tree growth. With the exception of samples from a soil profile at Paranatinga village, collected in February 1998, all samples were collected in September 2000. These composite samples were taken at 0-10 cm and 40-50 cm depth from five different points in each plot and air-dried. Soil was analyzed at the University of Florida's Analytical Research Laboratory for plant nutrients, pH, and soil organic matter content. Full results of these samples are given in Appendix 1. Changes in major chemical characteristics along a soil profile at Paranatinga village are illustrated in Fig. 4-2.

Results

Seedling Survival

In field environments, the lowest survival rate among the four species was observed for coconut seedlings (a comparison of seedling survival in fields is shown in Figs. 6-7). All other species planted in fields, however, also declined during the two years of the study, suffering mortality on the order of 20%. Great variability was observed in survival in different environments. Coconut, for example, ranged from 27% survival in Field 3 to 92% survival in the fertilized plot at Paranowaona village (Fig. 6-8) Likewise, the highest survival rate for soursop, 100%, was also observed in the fertilized village plot (Fig. 6-9). In contrast to coconut, however, which had the next highest survival rates in the unfertilized village plantings (74% at Paranowaona and 68% at Paranatinga), soursop had higher survival rates in Fields 1 and 3 (87% and 95%, respectively). While soursop's low survival (56%) at Paranatinga village may have been the result of damage by livestock, there was almost equally low survival in Field 2 (60%). In this field, at the two year monitoring individuals of both coconut and soursop were found dried up and dead. While this may have been due to drought stress in the previous dry season, this does not explain why soursop in the other fields or in the open environments fared much better.

For cupuaçu, the lowest levels of mortality were observed for seedlings planted under young banana groves (100% and 94% survival for the two young banana environments; Fig. 6-10). However, one plot of cupuaçu under a young banana grove was entirely killed by fire, and will be discussed separately in the following paragraph. Intermediate rates of survival were found for seedlings planted in the village environment (70%) and fields (mean of 76.5%). The poorest survival was observed in the environments where seedlings were planted under the shade of adult Brazil nut trees, near the edges of field (mean of 48.3%). Mortality in these sites was due to two principal causes: (1) low groundfires, which moved through the leaf litter following the opening of nearby clearings for agriculture, and (2) treefalls, most likely caused by greater wind turbulence at the edges of clearings. These sites turned out to be much more dynamic than first expected.

Fire was also responsible for 100% mortality in a plot of cupuaçu under banana, planted across the river from the village of Paranowaona. This event occurred when nearby fields were burned following cultivation of beans by the *feijão abafado* method. In this method, employed near the end of the rainy season, beans are broadcast under secondary vegetation, which is then slashed. After the beans are harvested in the dry season, a considerable quantity of fuel remains, and in this case, the field was burned to prepare it for manioc planting. Interestingly, the banana plants over the cupuaçu suffered little permanent damage from the fire. Although this method of cultivating beans would permit an economic use of the rows between tree crops, with the added advantage of providing an incentive to slash competing vegetation, it does pose a great fire risk to seedlings. The susceptibility of cupuaçu to fire indicates that fire prevention may be an important consideration for farmers who wish to plant this species beyond the bounds of their home gardens.

Tree growth

Village vs. field environments

It was not possible to compare the growth of cashew in different environments as seedlings in the village were strongly affected by anthracnose (*Colletotrichum gloeosporioides*), a fungal pathogen. Although the seed provenance of the cashew was a humid region of Amazonia, it was not resistant to the variety of anthracnose present on existing cashew trees, of local origin, planted around the village. For all the other species, growth was significantly greater in the open environment of Paranowaona village. While the growth of coconut and soursop in fertilized planting holes at this site was greater than those planted without amendments, this difference was not significant at the P = 0.05 level (Figs. 6-8 and 6-9). The fertilized planting pits did, however, have an effect on the precocity of flowering and fruit bearing (see for example Fig. 6-13). In the case of soursop, at two years all fertilized trees had flowers and 47% had both flowers and fruits, whereas only 83% of the open, unfertilized trees had flowers, and 11% had flowers and fruits. A similar effect of fertilization was observed when the coconut trees began flowering at 2 ½ years. Eighty-two percent of the trees planted in fertilized holes were flowering, while only 17% of those planted without fertilizer had flowers.

Growth of both coconut and soursop was significantly less at Paranatinga village (cupuaçu was not planted at this location). For soursop, there was no significant difference between growth at Paranatinga village and in the three field environments. This is most likely due to periodic damage to seedlings caused by free ranging livestock at that village. In fact, survival of soursop seedlings was the poorest at Paranatinga, with 56% surviving at two years (Fig. 6-9).

Performance of the trees in the different environments can best be related to shade levels, with the best growth being observed in the open environments of the villages, whether fertilized or unfertilized. A comparison of the means of visual shade estimates made in the different environments is shown in Fig. 6-11. In the case of coconut, the shaded environments of fields not only resulted in much lower survival rates (mean = 34%), but also much poorer growth (Fig. 6-8). Growth, expressed as number of leaflets/mature leaf, showed a strong negative correlation with increasing shade levels ($R^2 = 0.71$; Fig. 6-12(a)). Soursop also showed a strong negative correlation between growth (expressed as crown volume) and shade levels ($R^2 = 0.89$; Fig. 6-12(b)). While soursop appears to be able to continue surviving in shaded environments, no trees under shade were observed in flower or with fruit, in sharp contrast to the open, fertilized environment, where 100 % of the trees were flowering. For cashew growing in fields, some grew to heights of 3.5-5 m (often higher than competing vegetation) and flowered at the time of the two year monitoring. However, crown shape was far from ideal for fruit production, often consisting of one long vertical shoot, without side branches.

Although cupuaçu is a tree of the lower forest canopy in Southern Pará, and individuals in the forest understory commonly bear fruit, in the present study, best growth was observed in open environments (Figs. 6-10). However, unlike coconut and soursop, the negative growth response of cupuaçu, expressed as number of leaves/plant, to increasing shade levels was ambiguous ($R^2 = 0.32$; Fig. 6-12(c)). This may be an indicator of cupuaçu's greater tolerance of shade, although it may also reflect the effect of the dry season between the first and second years of the study. In this period, a great variation in response to drought was observed, with some plants maintaining all of their leaves, others shedding a good portion and some dying. Since such variation affects the appropriateness of using leaf number as an indicator of accumulated growth, additional measurements of stem diameter below the first branch were taken on 117 cupuaçu trees at 2 ½ years after planting. As an indicator of growth, stem diameter did show a somewhat better relationship with shade levels, with an R^2 of .49 (Fig. 6-12(d)). Nevertheless, the correlation between shade and growth indicators, whether leaf number or diameter, remains weaker than that observed for coconut and soursop (R^2 of 0.65 and 0.89, respectively; Fig. 6-12(a, b)). This weak correlation to increasing levels of shade may also be the result of cupuaçu's architectural plasticity. It was found that cupuaçu shows a clear response to differences in light quality between shaded and open environments (Fig. 6-14). In shaded environments cupuaçu plants exhibited a greater tendency to plagiotropic branching and leaf display, apparently for a more efficient utilization of available light. Open-grown plants, in contrast, besides having a more erect habit, showed a considerable degree of self-shading of leaves.

Cupuaçu in shaded environments

When the results for growth of cupuaçu in shaded environments (fields, under banana, and under Brazil nut trees) were analyzed in conjunction with the village environment, the differences between the shaded plots were found to be non-significant. However, due to the shade tolerance of cupuaçu, and its potential for planting in the lower strata of agroforestry systems, it was deemed important to analyze the different shaded environments separately. In this subsequent analysis, trees which had been recorded as being damaged by cutting, debris falls or herbivory at some time in the two-year study period were excluded, in order to reduce the number of external factors affecting growth. In this second analysis, significant differences in growth, expressed as number of leaves/tree, were found between some of the shaded environments (Fig. 6-15).

Overall, it can be said that the best combination of growth and survival was observed for cupuaçu planted under young banana groves (see for example Fig 6-14(b)). Cupuaçu planted under the denser shade of an old banana grove, in contrast, showed the poorest growth.

Soil Fertility

Field Microsites

In the conditions under which trees were grown in the fields, no effect of different microsites (ash concentrations, stumps or neutral) were observed on tree growth. However, it is possible that the potential effect which microsites could have on tree growth was masked by the effect of shade. Alternatively, at least for cashew, coconut and soursop, the small number of trees in the sample, further reduced by mortality, may not have been sufficient for obtaining relevant conclusions. For cupuaçu, however, seedlings may simply not show a response to the differences in levels of soil nutrients between field microsites. There is some evidence that seedlings of other Amazonian forest trees have weak or no responses to increased fertility, as has been observed for rubber (*Hevea brasiliensis*; Lourenço, 1988). Observations on native forest seedlings planted at INPA's

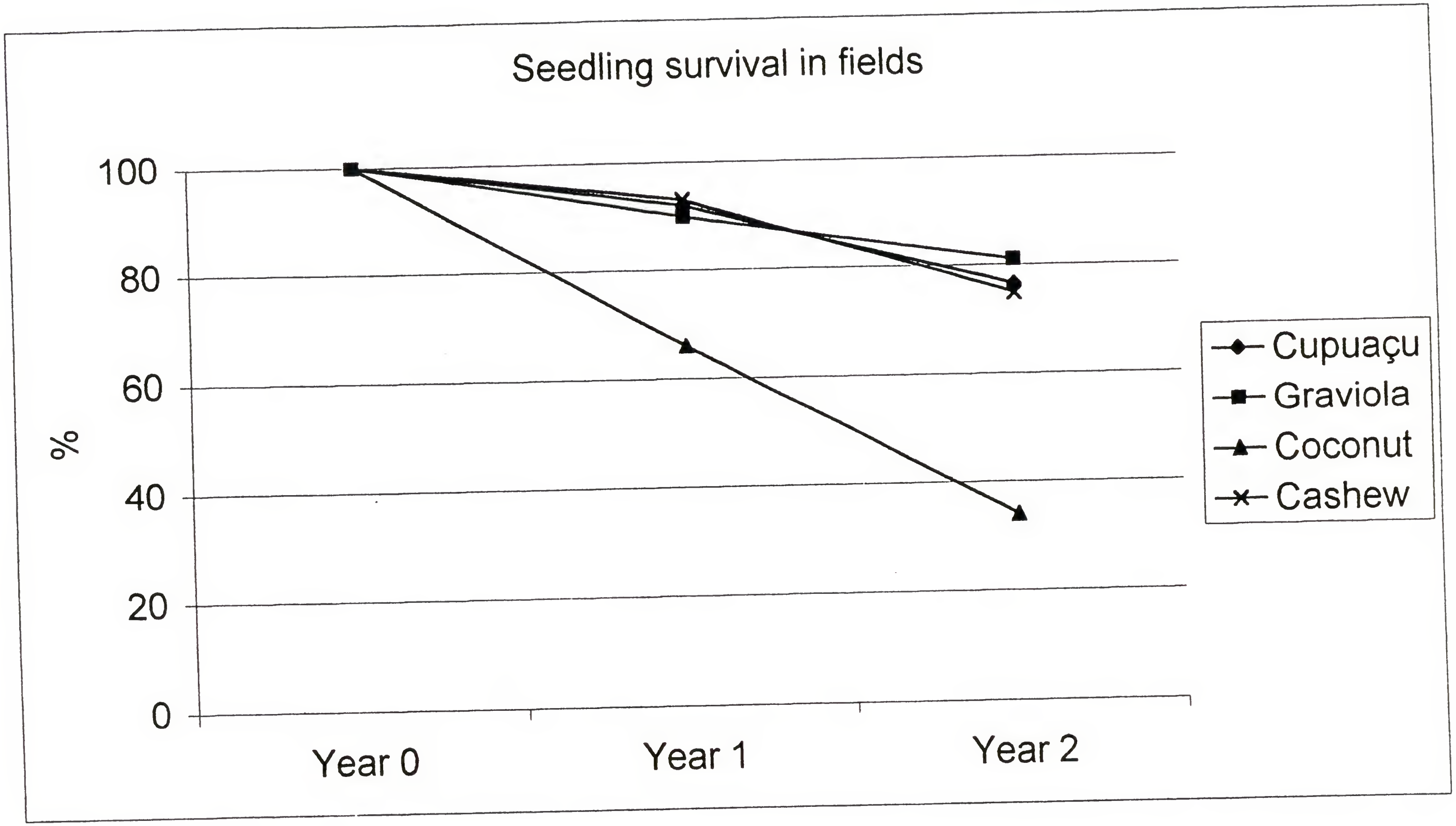


Figure 6-7: Survival of seedlings in slash-and-burn agricultural fields (mean of 3 fields). Experimental agroforestry plantings, Parakanã Reserve, Pará.

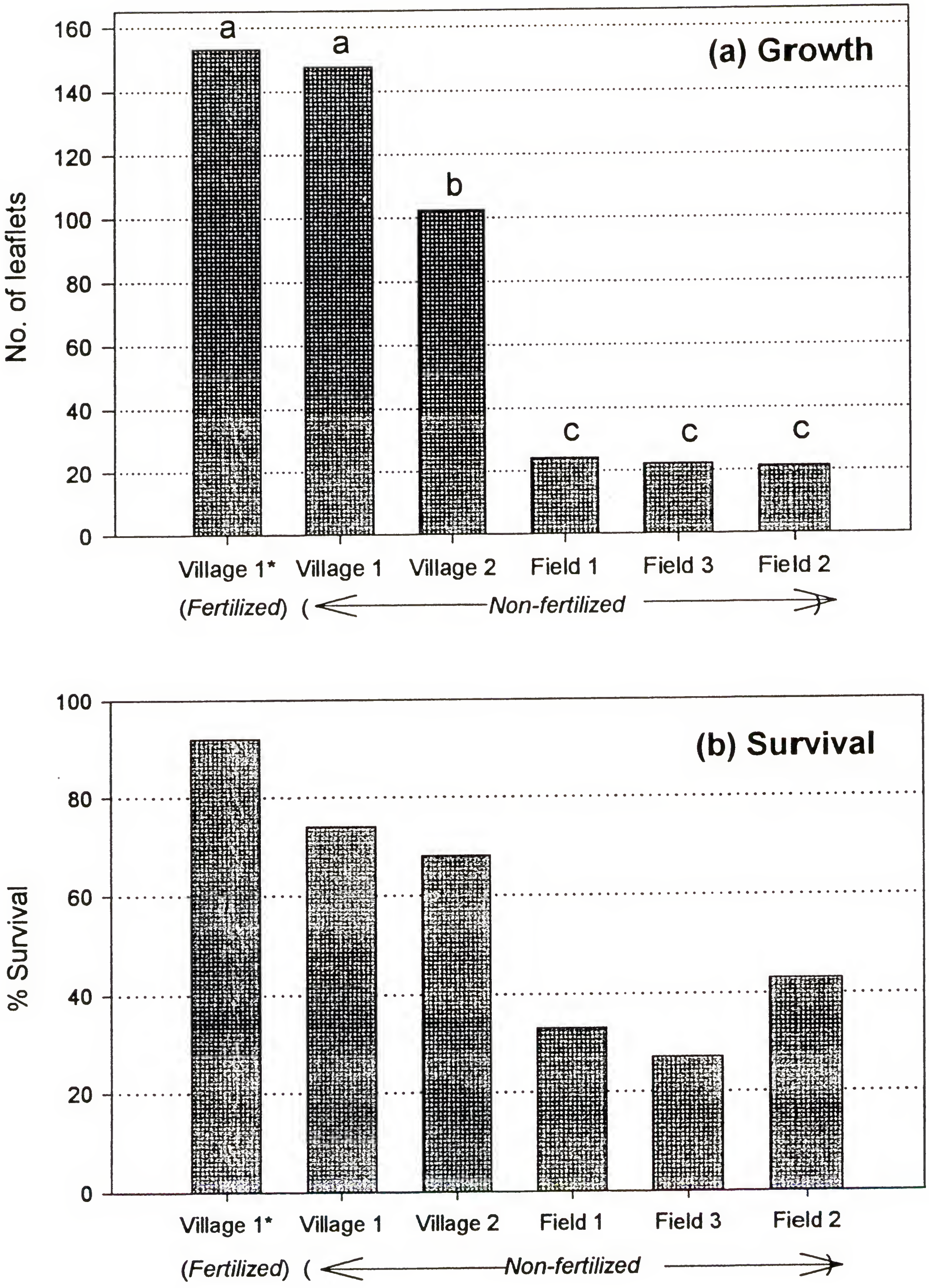


Figure 6-8: Variability in growth and survival of coconut (*Cocos nucifera*) in different environments, two years after planting. (a) Growth, expressed as no. of leaflets/ mature leaf. Bars with different letters are significantly different at $p<0.05$; (b) Survival, in percent.

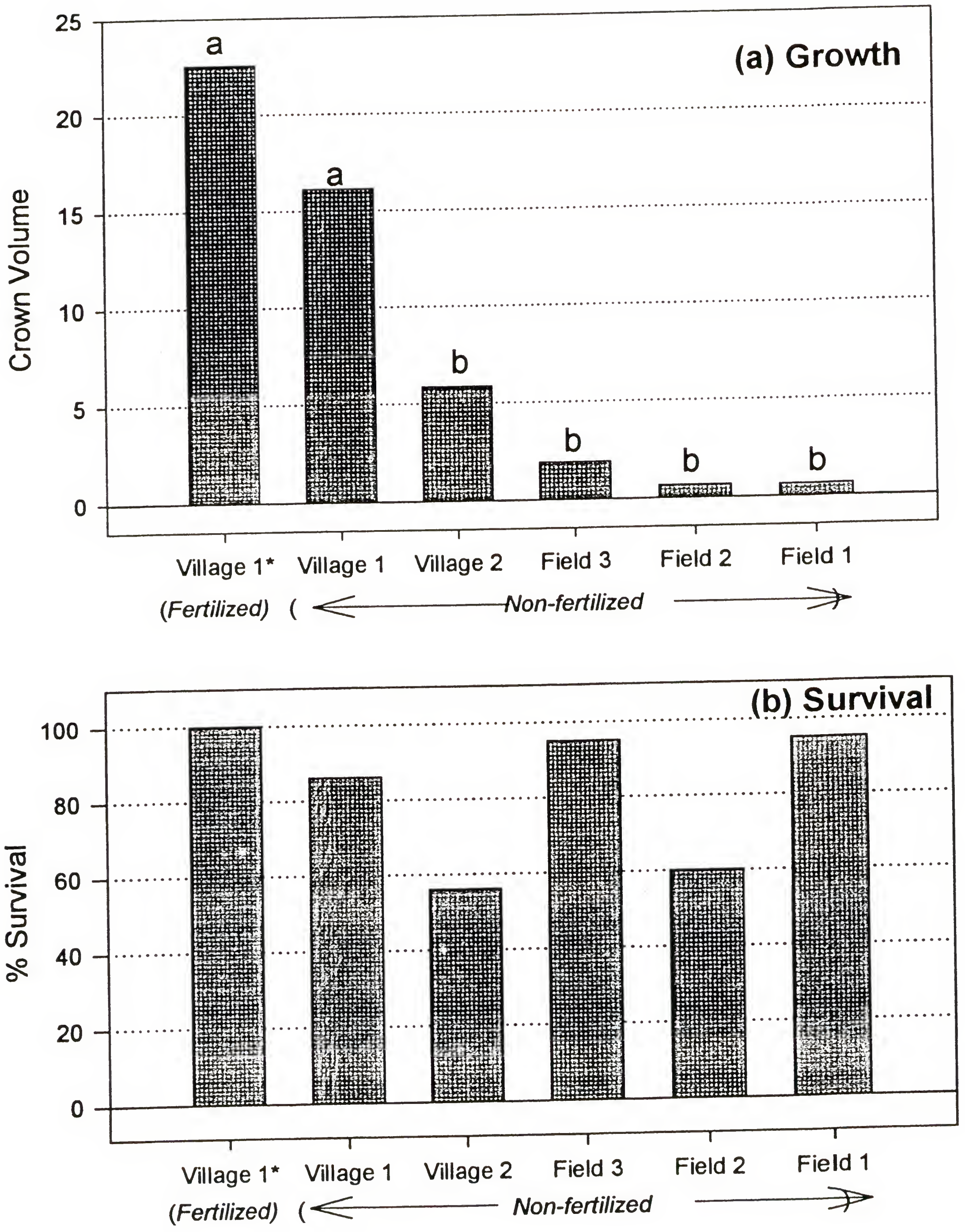


Figure 6-9: Variability in growth and survival of soursop (*Annona muricata*) in different environments, two years after planting. (a) Growth, expressed as crown volume. Bars with different letters are significantly different at $p<0.05$; (b) Survival, in percent.

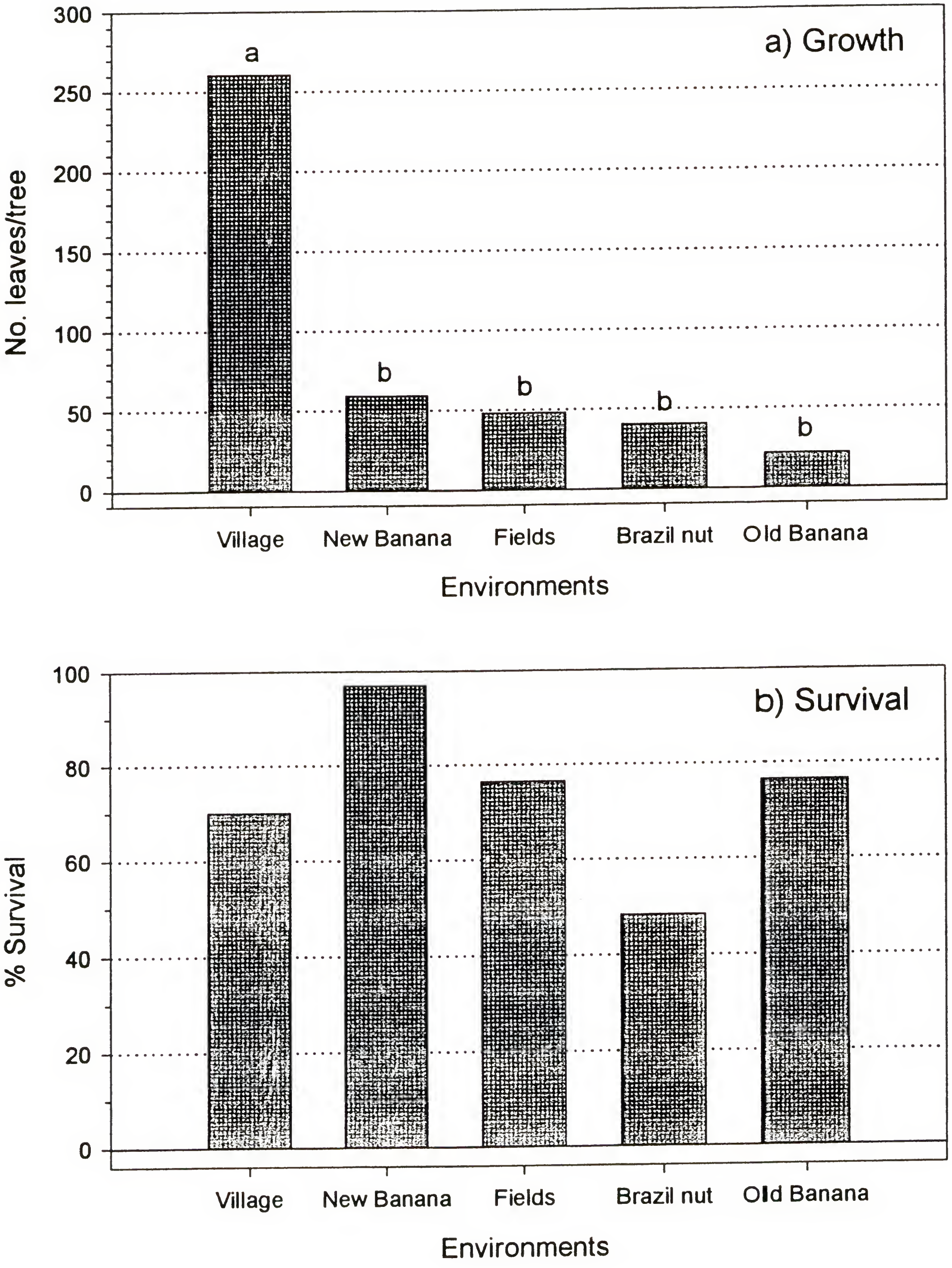


Figure 6-10: Variability in growth and survival of cupuaçu (*Theobroma grandiflorum*) in different environments, two years after planting. (a) Growth, expressed as crown volume. Bars with different letters are significantly different at $p<0.05$; (b) Survival, in percent.

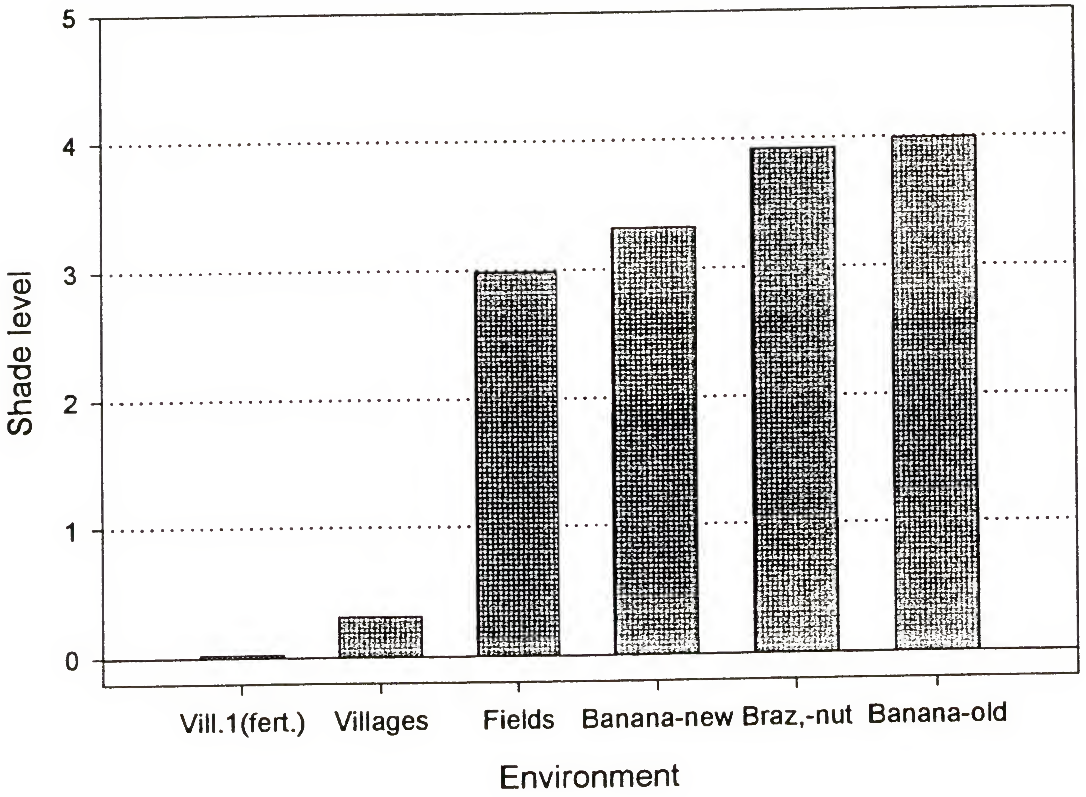
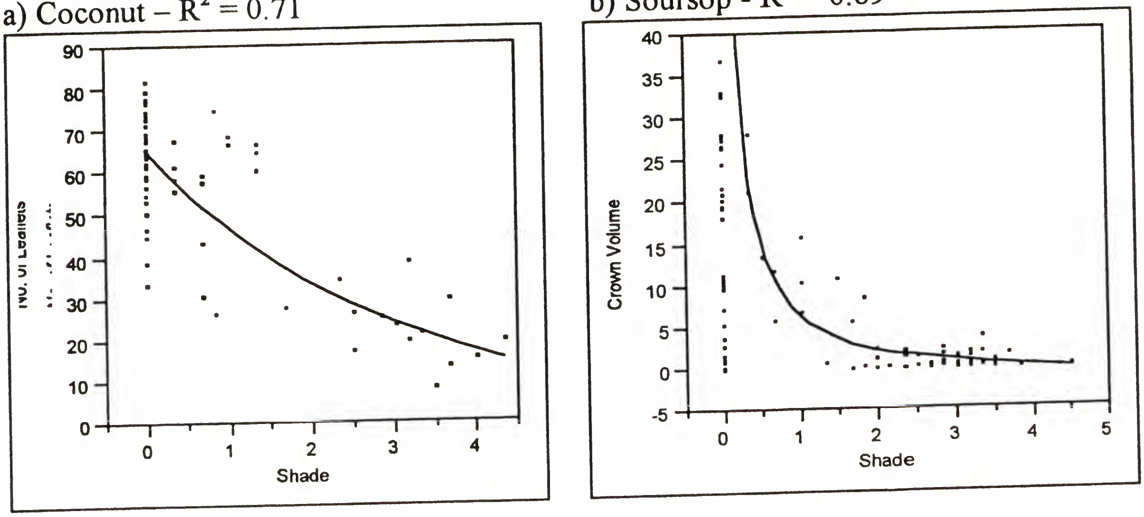
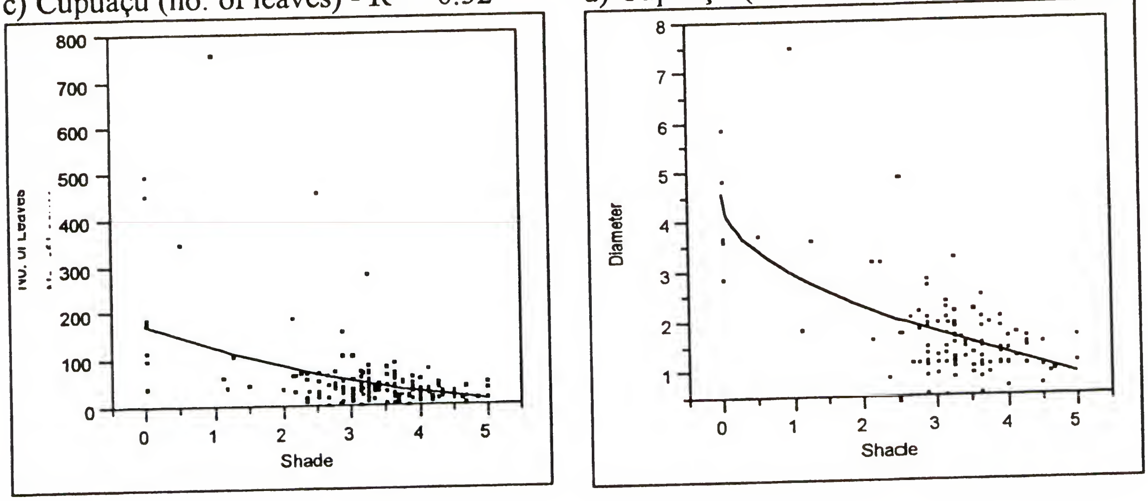


Figure 6-11: Means of visual shade estimates in different environments used for experimental agroforestry plantings, Parakanã reserve, Pará. (0 = no shade; 5 = full shade).


a) Coconut – $R^2 = 0.71$

b) Soursop - $R^2 = 0.89$


c) Cupuaçu (no. of leaves) - $R^2 = 0.32$

d) Cupuaçu (stem diameter) - $R^2 = 0.46$

Figure 6-12: Correlation of growth response of different fruit trees to varying levels of shade (0 = no shade; 5 = full shade) in experimental agroforestry plantings, Parakanã Reserve, Pará.

(a) Coconut, with growth measured as no. of leaflets/mature leaf
(b) Soursop, with growth measured as crown volume in m^3
(c) Cupuaçu, with growth measured as no. of leaves/tree
(d) Cupuaçu, with growth measured as stem diameter below first branch

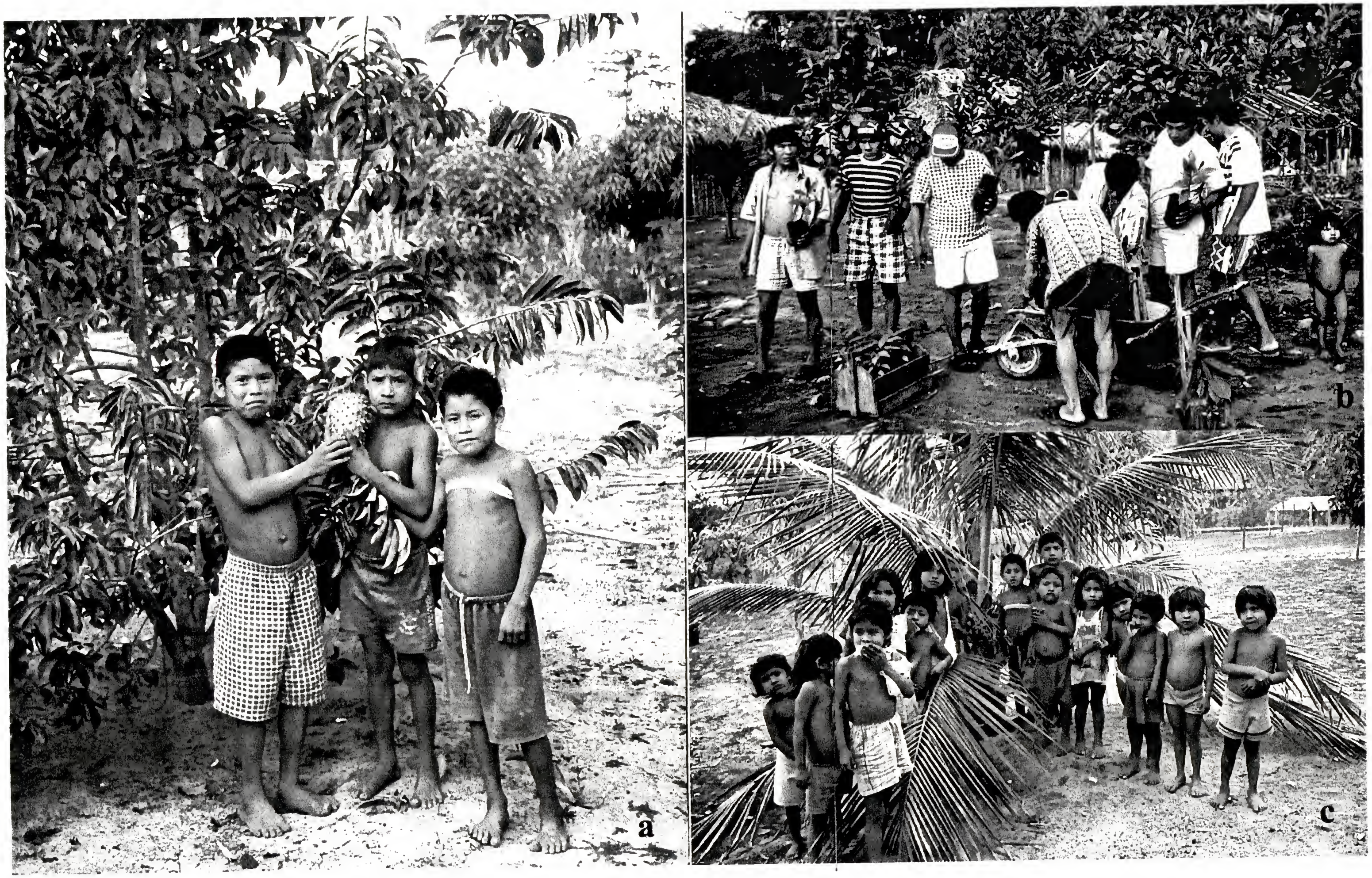


Figure 6-13: Fruit tree cultivation at Paranowaona village, Parakanã Reserve.
(a) Soursop (*Annona muricata*)planted in fertilized planting pit, at 2 ½ years; (b) Distribution of seedlings to villagers; (c) Coconut (*Cocos nucifera*) planted in fertilized planting pit, at 2 ½ years.

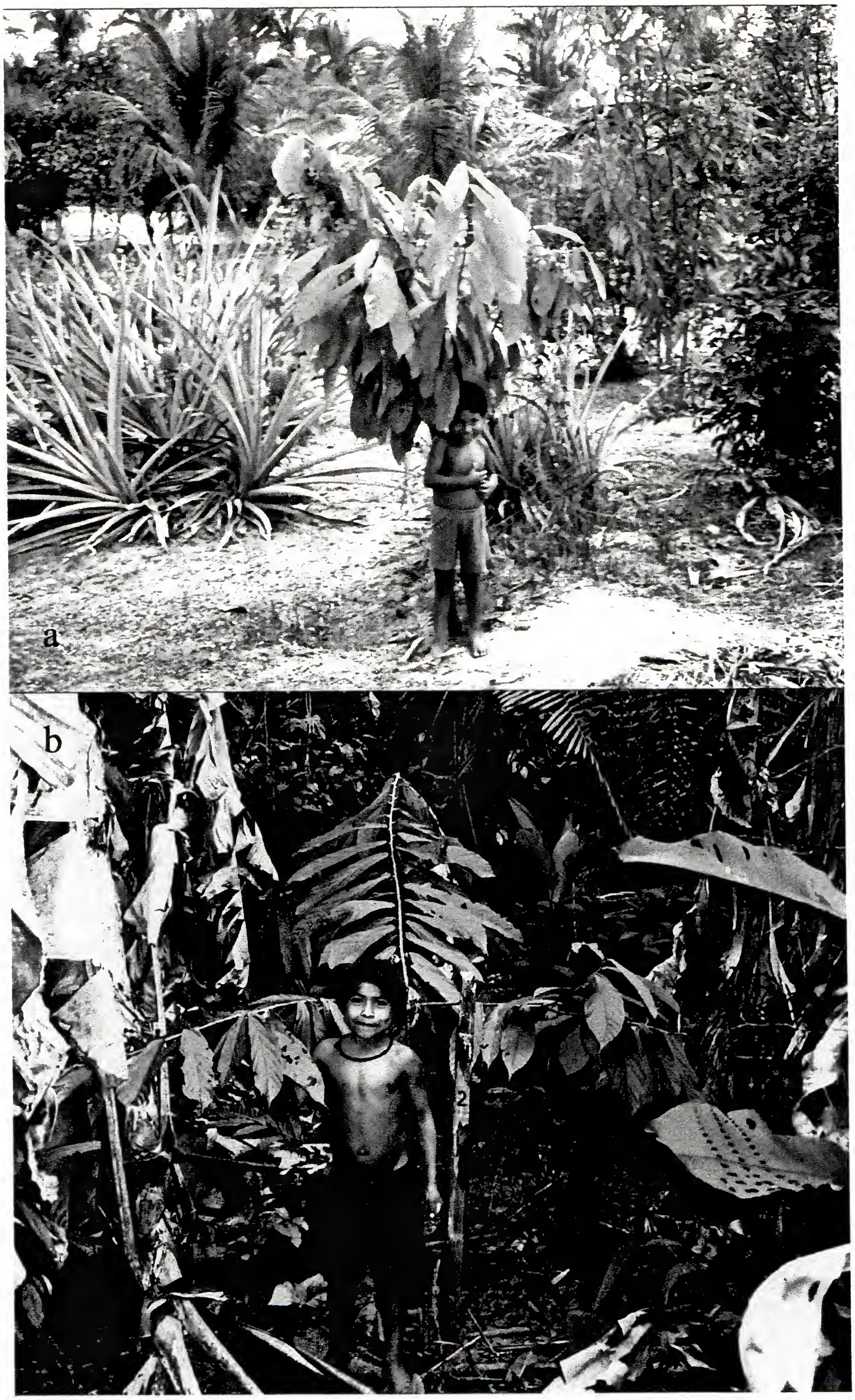


Figure 6-14: Changes in crown architecture and leaf display in cupuaçu (*Theobroma grandiflorum*) in response to different light environments, 2½ yrs. after planting. (a) Unshaded environment, near houses; (b) Shaded environment, under banana

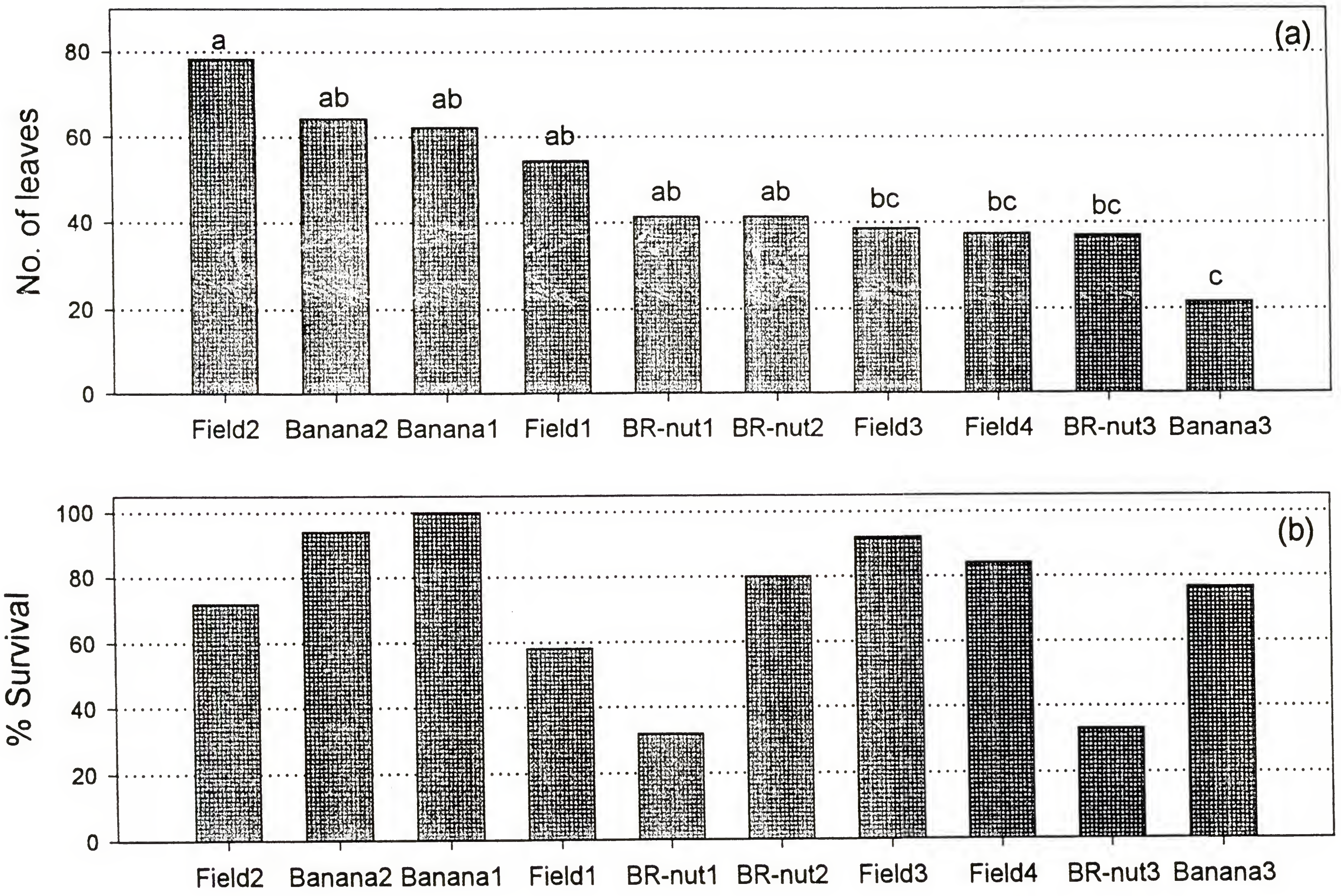


Figure 6-15 : Variability in growth and survival of cupuaçu in shaded environments, two years after planting. (a) Growth, expressed as no. of leaves/tree. Bars with different letters are significantly different at $p<0.05$; (b) Survival, in %.

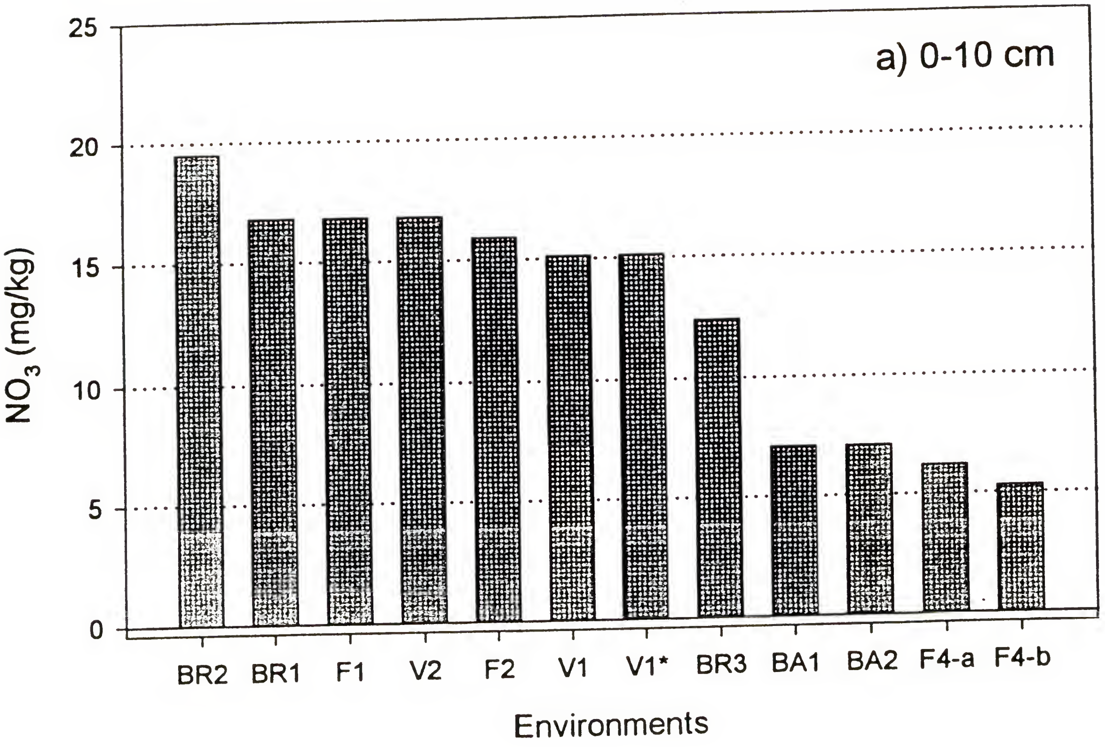
silviculture experiment station near Manaus found no difference in growth response between those planted in a slashed and burned site and a site which was only slashed (L.M.S. Magalhães, pers. com. 1987). Cupuaçu seedlings are in fact quite parsimonious in their requirements for nutrients. Studies at Embrapa-CPATU found that the maximum recommended dose of 10-28-20 fertilizer is 4 g per seedling, every two months. Higher doses or more frequent applications resulted in damage or death of the seedlings (Muller and Carvalho, 1997). In a fertilizer experiment carried out near Manaus, Lehman et al. (1998) found that when compared to Brazil nut, peach palm and annato (*Bixa orellana* L.), cupuaçu showed a very poor ability to preserve added phosphorus and cycle it through its litter.

Soil Nutrient Characteristics of Different Planting Sites and their Relation to Tree Growth

With the exception of Field 3, soil samples were collected in all the planting locations. In general, these samples indicate higher nutrient levels in soils near villages, where values ranged anywhere from 2 to 10 times that of most other environments (Table 6-1, Figs. 6-16,17,18). However, the locations Field 1 and Brazil nut 1 also ranked high in levels of nutrients, but these two locations are very near to the village of Paranaowaona, just off a major trail which leads to other fields and hunting and gathering trails. This is part of an area which is visited almost daily by villagers, principally women and children, for gathering of firewood and other materials. Chickens were also observed foraging in this area. Nevertheless, the higher levels of nutrients in these two sites did not appear to have

Table 6-1: Description of experimental agroforestry plots where soils samples were collected, Parakanã Reserve, Pará

Abbreviation	**Plot Description**	**Other Information**
F1	Field 1	Field nearby village
F2	Field 2	
F4-a	Field 4-A	
F4-b	Field 4-B	
BA1	Banana 1: new banana grove	Located downslope from Field 1
BA2	Banana 2: new banana grove	
BR-1	Brazil nut 1	Located along trail, next to Field 1
BR-2	Brazil nut 2	Between Fields 1 and 2
BR-3	Brazil nut 3	Located off trail, before Field 2
V1	Village 1	Paranowaona
V1*	Village 1: fertilized planting pits	
V2	Village 2	Paranatinga



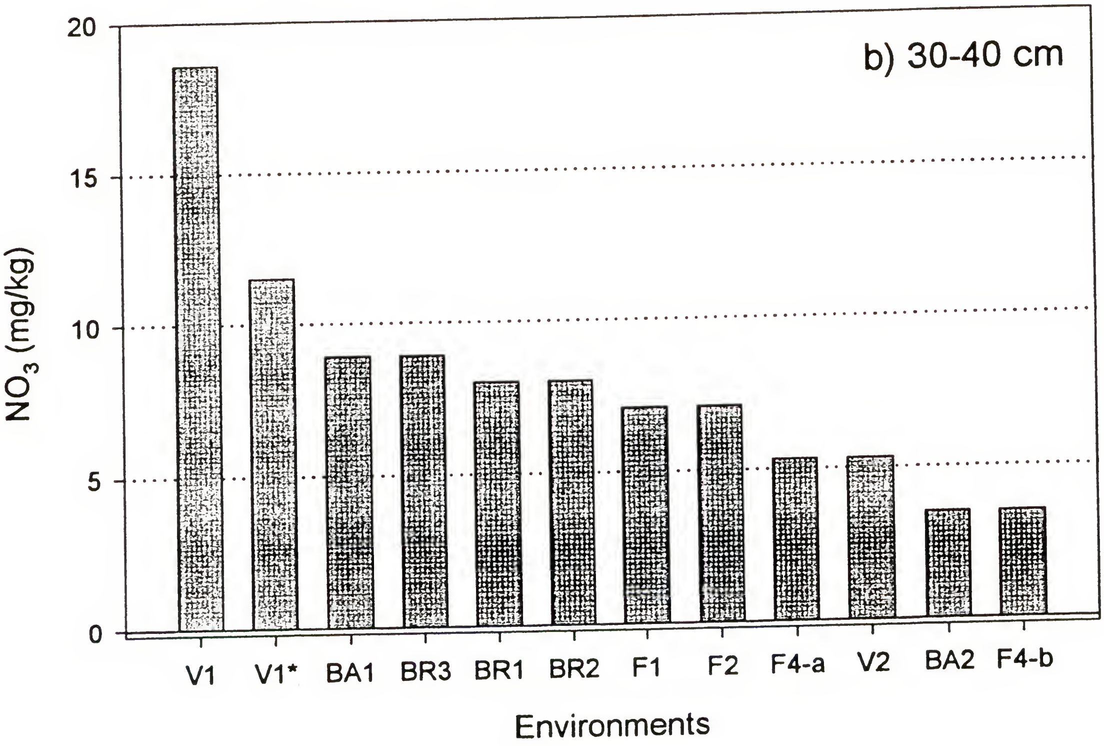
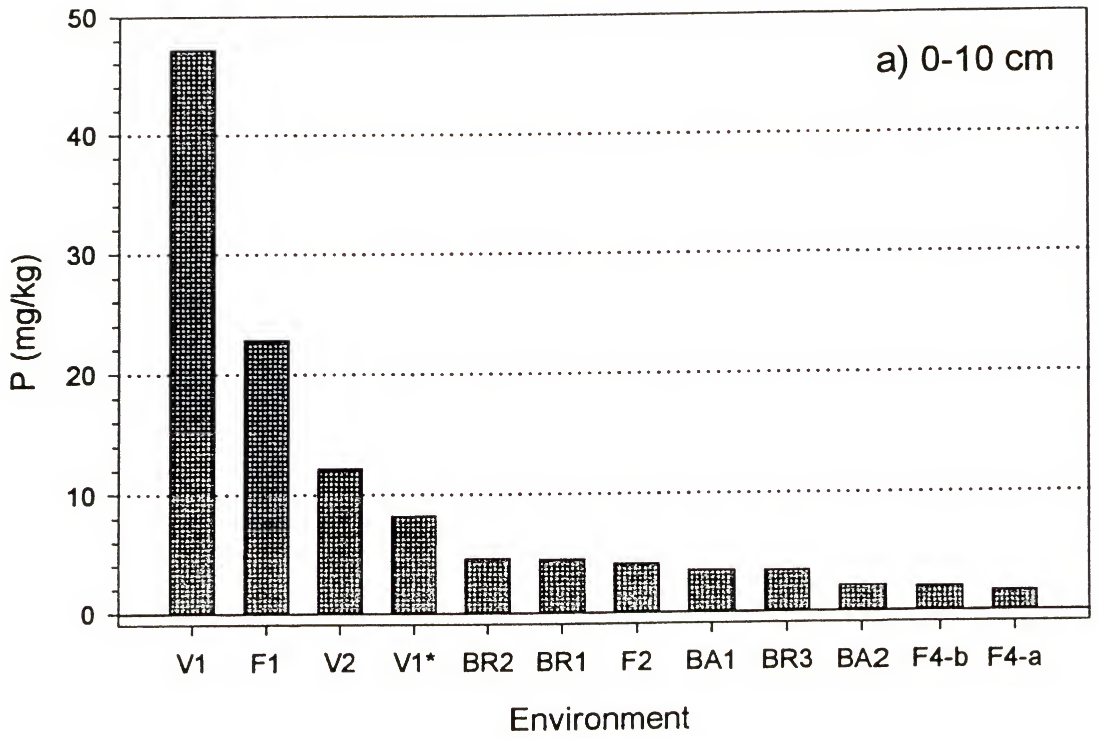


Figure 6-16: NO_3 content of soils in different environments used for experimental agroforestry plantings, Parakanã Reserve, Pará (a description of environments is given in Table 6-1). (a) 0-10 cm depth; (b) 30-40 cm depth.



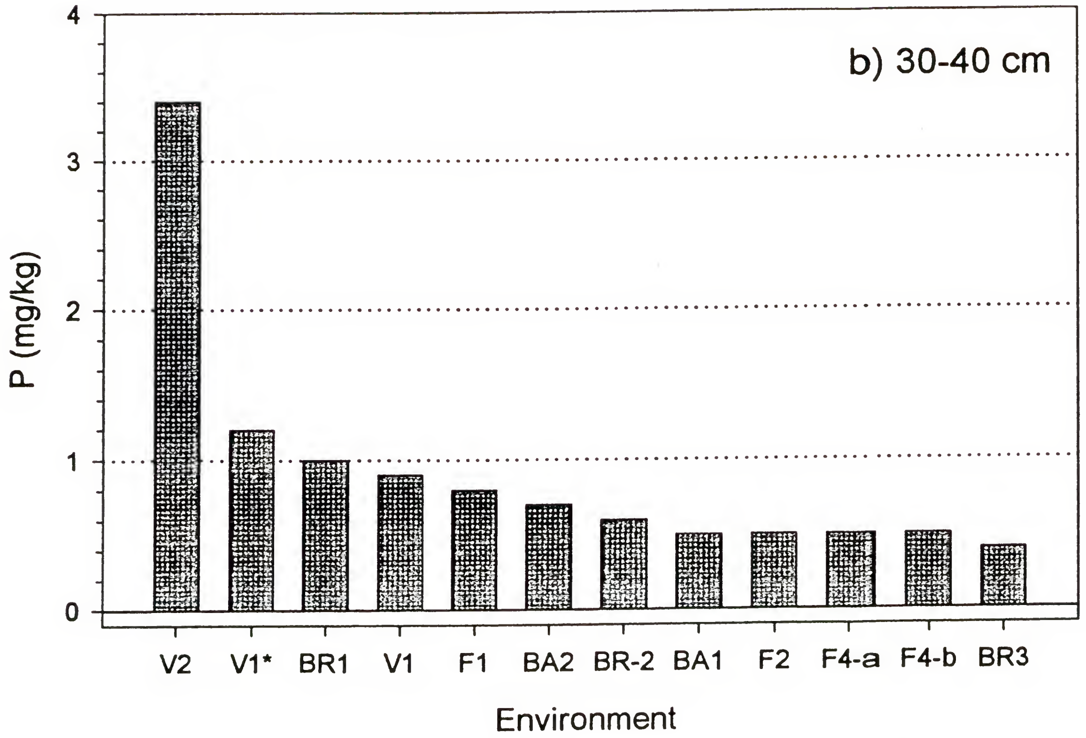
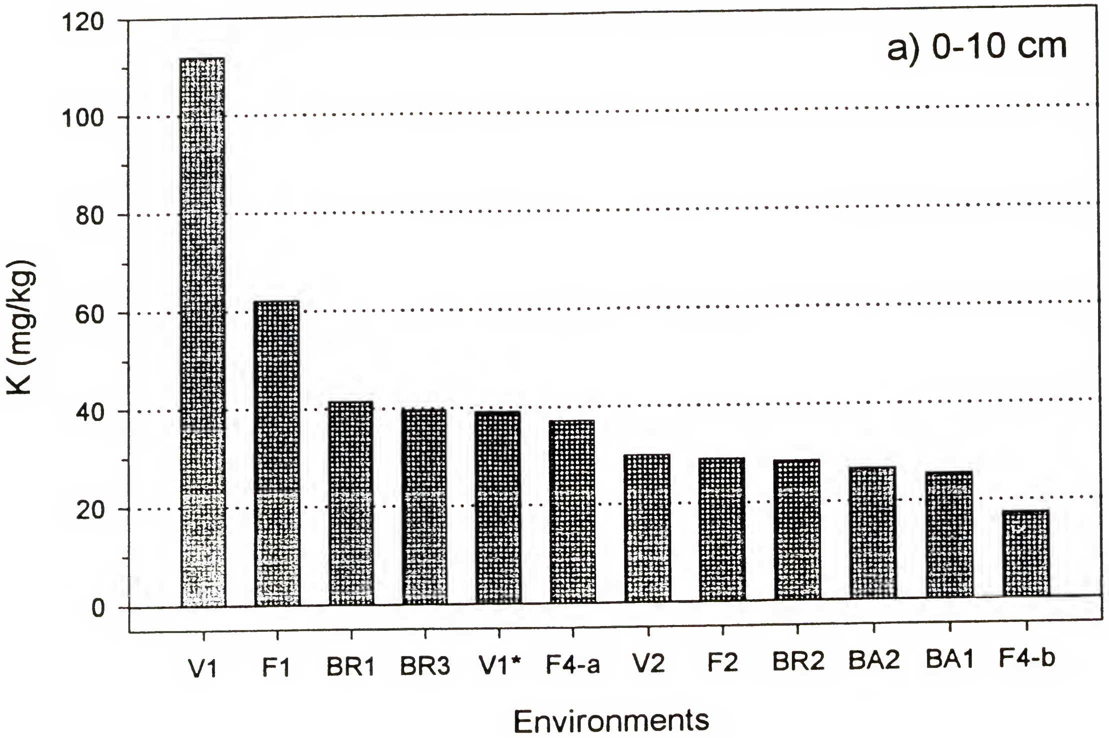


Figure 6-17: Phosphorus content of soils in different environments used for experimental agroforestry plantings, Parakanã Reserve, Pará (a description of environments is given in Table 6-1). (a) 0-10 cm depth; (b) 30-40 cm depth.



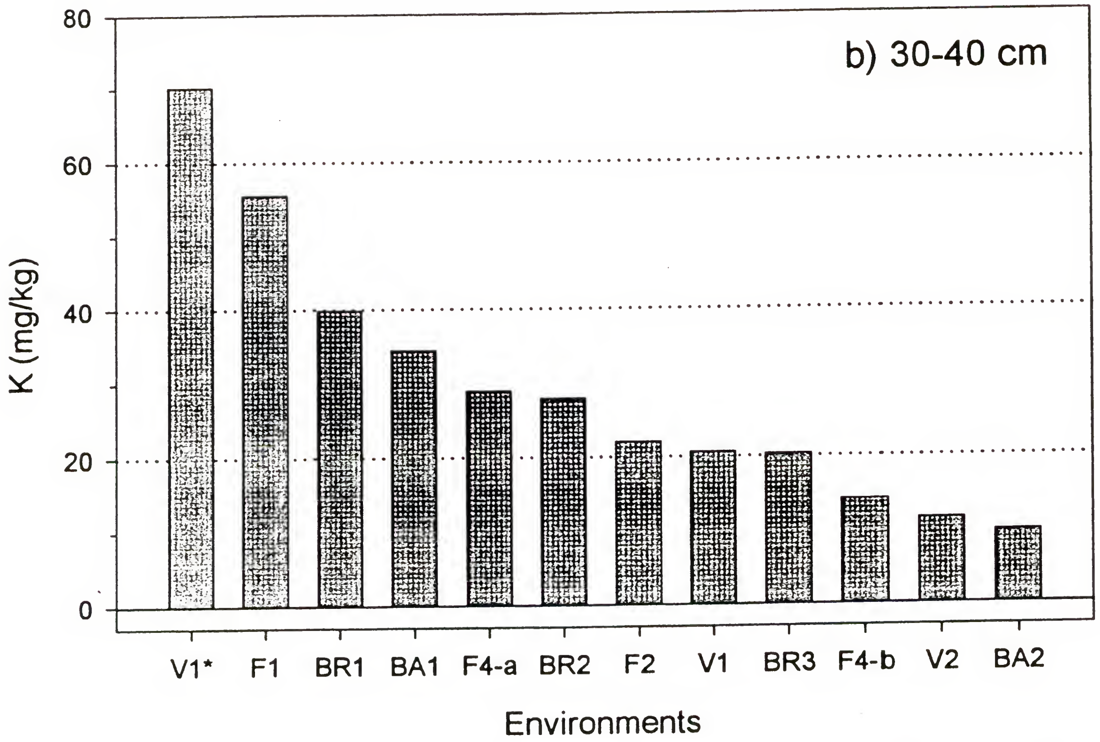


Figure 6-18: Potassium content of soils in different environments used for experimental agroforestry plantings, Parakanã Reserve, Pará (a description of environments is given in Table 6-1). (a) 0-10 cm depth; (b) 30-40 cm depth.

an effect in terms of increasing cupuaçu growth, in comparison to other shaded environments more distant from the village (Fig. 6-15).

While the site where trees were planted in fertilized planting pits at Paranowaona village (V1*)[10] was generally lower in nutrients (with the exception of potassium at 30-40 cm depth), this site showed superior growth of coconut and soursop (Figs 6-8,9), as well as more precocious flowering and fruiting. This would seem to indicate that fertilizing planting pits with locally available materials can compensate for lower soil fertility.

Discussion and Conclusions

Given the rapid growth of successional vegetation in abandoned fields, more light-demanding species of fruit trees should only be planted in such environments if there is a strong commitment to manage them on the part of the farmer. Even with the farmer's commitment to management, the earlier the trees are planted in the cropping cycle, the better. More shade tolerant species such as cupuaçu can survive and grow in more shaded environments, and may be a better option for farmers with limited labor availability. However, farmers should be aware that better growth will be achieved with greater management inputs. At low levels of management, consisting of slashing competing vegetation initially at three month, then six month intervals, cupuaçu performed reasonably well, whereas coconut and soursop did poorly. Although cupuaçu planted in the open showed the best growth, this environment may also be riskier in terms of seedling survival. Two farmers in the region reported heavy mortality of cupuaçu in the dry season, when seedlings were planted in the open. One of these farmers, who lost almost 80% of the 250 seedlings he planted, recommended that unless irrigation is available, cupuaçu should only be planted in the shade.

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[10] This site is located slightly upslope from the houses, between the village and the house for Programa Parakanã employees.

Although use of locally available fertilizer (ashes, manure and bones) in planting pits did not result in a statistically significant difference in the growth of soursop and coconut in open environments, fertilized trees came into bearing sooner. Such forms of fertilizer, which are generally available to small-scale farmers, could be important for establishing and maintaining the productivity of more nutrient-demanding fruit trees.

Ideally, locations closer to the farmer's home should be chosen for fruit tree planting, as the trees can be more easily managed and protected from fire. At Paranowaona village, fires which spread from burning fields entirely killed one plot of 15 cupuaçu trees planted under banana, and partially destroyed a plot under Brazil nut trees. Unfortunately, a growing tendency in Pará and other regions of Amazonia is for resource-poor farmers to follow a cropping cycle with pasture establishment, with the result that their agricultural fields, where trees could most easily be planted, become progressively more distant from the roadside and their houses. The presence of pastures, which are very susceptible to fire in the dry season, is a further complicating factor. Pasture fires often give rise to low intensity forest fires which spread slowly through leaf litter. As the thicker bark of adult trees is usually sufficient to protect them from damage, the chief impact of such fires is on seedlings and saplings, and young plantations of fruit trees such as cupuaçu would be equally at risk.

In the case of cashew, before inclusion of this species in extension projects, care should be taken to identify local varieties which are resistant to the local strains of anthracnose, or testing should be carried out on seed from different provenances to determine their adaptability.

Further Inquiry

While cupuaçu growth was best in the unshaded village environment, this site also had the highest phosphorus and potassium levels in surface soils (0-10 cm depth), as well as the highest level of NO_3 at the 30-40 cm depth (Figs. 6-16, 17,18). In order to separate out the possible effects of light and nutrients, and their interaction, growth of cupuaçu with and without fertilizer in shaded environment merits a closer examination. From a farmer's point of view, recommended doses of chemical fertilizer for cupuaçu are quite low, so it should not require much of locally available fertilizers such as manure or ashes to provide an equivalent amount of nutrients.

Nutrient enrichment of surface soils, principally with phosphorus and potassium, was observed in the proximity of Paranatinga village, where the greater number of soil samples were taken. A more specific study could determine the areal extent of this effect and its implications for cultivation of fruit trees around homes.

Alternatives for using the space between tree rows while the trees are young should also be explored. In Eastern Amazonia, this could be the planting of cowpeas in the local practice of "feijão abafado" (similar to the "frijol tapado" of Central America). However, this practice leaves a significant amount of fuel at the end of the dry season, posing a fire risk.

CHAPTER 7
AGROFORESTRY, COMMUNITY DEVELOPMENT AND THE PARAKANÃ: AN ASSESSMENT

The Perspectives for Agroforestry as a Component of Parakanã Farming Systems

The Parakanã were found to be engaged in a market economy, to the extent that labor efforts could be emphasizing commercial crops or extractive products to the detriment of subsistence crops (Programa Parakanã, 1996). Planting fruit trees in an agroforestry system, complementing existing agricultural practices, presented itself as a means of stabilizing or improving this relationship, by creating alternative sources of income and increasing fruit production for community consumption. With this in mind, an agroforestry experiment was established as a pilot project to test the incorporation of different methods of tree planting in the Parakanã's farming systems (Chapter 6). Besides the fruit trees used in this experiment, a number of seedlings of other species were also distributed to villagers or planted in the vicinity of the FUNAI posts, nearby the villages. Most of the seedlings were produced in rustic nurseries at Paranowaona or Paranatinga villages, from seeds obtained in Manaus, Belém or Tucuruí, with additional seedlings obtained from the municipal nursery in Novo Repartimento. While these seedlings were not planted according to an experimental design, observations on their performance were judged useful for the discussion of the potential role of agroforestry for Parakanã communities. These observations are grouped in Table 7-1. Included in these observations is information from plantings done prior to the present project, by a FUNAI

Table 7-1: Observations on the performance of assorted fruit trees planted around Parakanã villages

Species Name (English/Portuguese); Latin	**Time to fruit-bearing**[a]	**Comments**
Abiu *Pouteria caimito*	3-4 yrs.*	Seedlings grew well in full sun.
Avocado/abacate *Persea gratissima*	Variable, according to cultivar	Seedlings planted in full sun, and which were not watered, died in the dry season.
Barbados cherry/acerola *Malpighia emarginata*	1-2 yrs. for cuttings	A prolific producer, but is not very appreciated by children. Much variation in fruit size and acidity
Cashew/caju *Anacardium occidentale*	1-4 yrs., according to cultivar	Much appreciated by children. Seedlings are very resistant-even small seedlings (in paper cups) had reasonable survival.
Coconut/coco *Cocos nuciferum*	3 yrs.* (dwarf varieties)	Principal use is the "water" in green coconuts
Cupuaçu *Theobroma grandiflorum*	4-5*	Small seedlings planted in full sun had very low survival. Larger seedlings (±50 cm high, 8 leaves) had 70% survival.
Ice-cream bean/ingá-cipó *Inga edulis*	2½ yrs.	Trees showed signs of drought stress in dry season.
Jackfruit/jaca *Artocarpus heterophyllus*	?	Seedlings grew well in full sun, with good vegetative growth in first years
Lime/limão *Citrus aurantifolia*	3 yrs.	

Table 7-1: Observations on the performance of assorted fruit trees planted around Parakanã villages

Species Name (English/Portuguese); Latin	**Time to fruit-bearing**[a]	**Comments**
Malay apple/jambo *Syzygium jambos*	5*	
Mango/manga *Mangifera indica*	4+yrs*, according to cultivar	Very much appreciated by children and adults. In Maroxewara, children harvest unripe fruit and hide in unhusked rice until ripe.
Nance/muricí *Byrsonima crassifolia*	?	Apparently very drought resistant, as observed flushing new leaves in the dry season
Papaya/mamão *Carica papaya*	9 mos.	Much appreciated by women and children
Peach palm/pupunha *Bactris gasipaes*	3-4 yrs.*	
Soursop/graviola *Annona muricata*	< 2 yrs.	Eaten by children, but not highly appreciated
Star fruit/carambola *Averrhoa carambola*	< 2 yrs.	Seedlings have slow initial growth, and small seedlings did very poorly. Planting larger, top-pruned seedlings, had good results.
Sugar apple/ata *Annona squamosa*	< 2 yrs.	Seedlings have slow initial growth, and small seedlings did very poorly. Good results were obtained with larger, older seedlings
Wild sweetsop/biribá *Rollinia mucosa*	3-4 yrs.*	Trees showed signs of drought stress in dry season.

a - time from date of planting; * - estimate from the literature or observations in other locations employee, José Pedro dos Santos, and by the Coordinator of the Education Subprogram, Cláudio Emídio Silva, with the help of teachers and children. Efforts to establish fruit trees have been well-received by Parakanã leaders, who have expressed a definite interest in planting more fruit trees around houses for domestic consumption. While some of this interest is due to the results of early-bearing perennials such as papaya and ice-cream bean, the Parakanã have also had many opportunities to see other fruit trees being cultivated on neighboring farms, and the two oldest villages have a number of mango and cashew trees bearing fruit. However, despite the interest of the Parakanã, not all locations present ideal conditions for tree planting. In the three villages which have cattle, mules or horses, these animals caused serious damage to seedlings planted around the homes, with mango seedlings being particularly appetizing. Although separate areas are fenced off for pasture in Paranatinga and Maroxewara villages, these areas have become inadequate, both due to herd growth and pasture degradation, from overgrazing and lack of maintenance. As a result, animals are allowed to graze in the village area. In the case of Inaxyanga village, an area of pasture was partially fenced, but the cattle were brought before the fence project was finished. However, the Programa Parakanã's coordinator for this village has plans to fence around the entire village, as has been done to the post, to exclude cattle. At Maroxewara village, there are plans to fence an area between the village and the post for planting fruit trees.

Although cattle serve no specific purpose in Maroxewara and Inaxyganga villages (they are occasionally milked by villagers in Paranatinga, with the help of an employee), because of their isolation in the rainy season, mules are quite important for transporting both goods and people, especially during the Brazil nut harvest. Overall, however, these three villages provide a demonstration of what can happen when indigenous communities, in aspiring to regional ideals, decide they want to raise cattle, yet do not have the knowledge of what is required for their care. The status attached to owning cattle makes them more important than fruit trees, and makes even their occasional attacks on field crops tolerable.

It is perhaps too early to determine what will be the Parakanã's level of adoption of agroforestry systems for commercial production. Such systems would require more extensive tree planting in fields, beyond the bounds of the village. Given the the little maintenance which the Parakanã give to their fields, and the relatively short interval before they are allowed to return to fallow, planting more light-demanding species in these locations is not recommended. Coconut and soursop, two species that are commercially important in local markets, showed very poor results when planted in fields for the agroforestry pilot experiment. The best option, if any, is to plant shade tolerant species such as cupuaçu. Initially, the Parakanã were not very excited about planting cupuaçu. Their enthusiasm picked up, however, following the 1998-1999 rainy season, when wild trees did not produce any fruit, yet a limited amount of fruits from settlers' home gardens were observed being sold in markets.

An idea which has been discussed for increasing the Parakanã's income is the purchase of fruit pulp processing equipment, which would be installed at the Programa headquarters in Tucuruí. Pulping machines can be purchased in a variety of sizes, in accordance with production demands. However, given the seasonal (and erratic) production of cupuaçu, investments in a machine and other necessary equipment and infrastructure (freezers, pulp bagger, and tiled work area), as well as an operator, would only be justified if other fruits besides cupuaçu were to be processed. Based on local market preferences, some of these fruit could be soursop, mombin, murici, acerola, and guava. However, the planting and care of these species, in the form of an agroforestry system, would require that the Parakanã devote a greater amount of time and effort to tending their fields than is now customary.

The Programa Parakanã as an Agent of Community Development

When the Programa Parakanã was established in 1987, the Parakanã had ceased to practice agriculture and were entirely dependent on FUNAI for the provision of food. Malnutrition was rampant, especially among women and children, exacerbating existing medical problems. Therefore, along with routine vaccinations and malaria control, one of the first health actions of the Programa Parakanã was to institute a food supplementation program for young children and pregnant and lactating women, in the form of a porridge based on milk, cereal starch, and sugar. Concurrently with its health actions, the Programa Parakanã employed an agronomist, who along with other employees, worked to help the Parakanã return to self-sufficiency in food production. Along with food production, efforts were also made in the direction of economic self-sufficiency. As a result of these efforts, the situation of food production has improved substantially for the Parakanã over the past decade.

The support for various commercial agricultural and extractive activities was initiated by FUNAI and given continuity by the Programa Parakanã (see Ch. 5 for more details on the history of this support). In 1989, FUNAI personnel contracted a firm to plant cacao at Paranatinga and Maroxewara, the two villages which existed at that time, with 4.5 ha being planted at each location. However, these plantations did not inspire the Parakanã to become cocoa producers, and the cacao trees are now growing under dense secondary forest, or were burned by escaped pasture fires. Harvesting of the fruits is done strictly for home consumption of the pulp which surrounds the seeds. In 1991, the agronomist employed by the Programa Parakanã helped the members of Paranatinga village in planting coffee, annato, and citrus. However, by 1998 the only trees which appeared to have survived were those planted around the FUNAI post. Other introduced crops have had a much greater impact on the Parakanã lifestyle and economy, as has been the case of rice. Besides becoming a source of income, rice has also become part of the Parakanã diet, principally in the months following harvest, and when there is a shortage of cassava. Maize, a traditional crop for the Parakanã, was reintroduced by FUNAI, and has also become an important commercial crop.

Income and Nutrition: Gender Issues in Parakanã Society

In any given community, the success in mastering new agricultural production methods, establishing commercial relations, and obtaining a greater income would seem to be the recipe for an improved standard of living and greater well-being on the household level. However, in the case of the Parakanã, this has often not been the case.

In 1998, for example, the greatest frequency of cases of malnutrition was found in Paranatinga, the village with the greatest income. This phenomenon is not something recent - this village had a reduced production of food crops in 1989/90 and 1990/91, due to the channeling of efforts towards the sale of bananas, açaí and Brazil nuts (Programa Parakanã, 1994). A report for 1991 records that this village sold 2,451 banana bunches through the month of August, and 693 18-liter cans of açaí (Programa Parakanã, 1991). In this same year, a biometric survey of nutritional status[11] found that only 38.04 % of the population of Paranatinga could be considered normal or well-nourished, whereas 61.53% of the population of Maroxewara, the only other village at that time, was considered normal. The better situation at Maroxewara was attributed to its greater distance from the Transamazon Highway and a lesser preoccupation with commercial activities, along with the participation of the men in the production of manioc flour. In the case of Paranatinga, signs of malnutrition were restricted to women and children and were not seen in adult males. For children under 10 years of age, 100% of the girls and 95.2% of the boys exhibited malnutrition. Although this survey was not repeated, observations by Dr. Menezes and health agents are that the present situation at Paranatinga continues to be poor. Internal disagreements at Paranatinga led this village to fission with the creation of two new villages, Paranowaona (in 1997) and Itaygo'a (in

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[11] This survey was carried out by medical students from the Federal University of Pará, under the guidance of Dr. Raimundo Camurça Menezes, coordinator of the Programa Parakanã's health subprogram, and professor at that institution.

1998). Today, these two villages are self-sufficient in food, and manioc surpluses at Paranowaona have helped tide both Itaygo'a and Paranatinga over times of shortage.[12]

In order to understand the apparent relation between malnutrition and commercial agriculture and extractive production, an effort was made to examine behaviors that occur at the home and village level. For this, the principal source of information was the employees of the Programa Parakanã who participated in the quotidian of the villages, principally the teachers and health agents. For the most part, it was found that the dietary disequilibrium associated with the intensification of commercial activities can be attributed to the unequal control of resources. The harvesting of Brazil nuts, for example, is an activity that involves all the members of a village, yet it is the men who have total control over the proceeds of the sale. In general, although female labor is essential to agricultural and extractive production, women have little or no participation in the monetary results. Parakanã society is strongly patriarchal, and the privileges of adult men extend to a priority over food, so that women and children eat last. In the villages with the greatest nutritional problems it was a common occurrence for women to take their porridge supplement to divide with their husbands at home, over the protests of the health personnel. The logic of patriarchal domination appears to extend to the extreme: men not only have priority over food, but also have the right to sell items which would otherwise be part of the diet of women and children. The most serious result of the sale of products is the loss of foods traditionally consumed in the village. In villages with a greater involvement with the regional economy there is a definite impact on the availability of such foods. In Paranatinga and Paranowaona, for example, all of the Brazil nut harvest was sold, and none was saved for future consumption. This practice eliminates a food item which was an important component of the diet in the not too distant past, when the bounty of Brazil nuts was probably consumed over a period of several months. Initiatives to leave a small portion of the Brazil nut harvest for consumption by women and children in the school met with a certain resistance on the part of the men. Information from teachers is that a similar process of restricting domestic consumption in favor of commercialization occurs with bananas, and possibly also with açaí. Although açaí is not a traditional food for the Parakanã, today it is well accepted. To increase consumption at the village level, the Programa Parakanã purchased and installed a simple açaí processing machine at Paranatinga village, so that when this product is harvested for sale, a portion can also be immediately consumed.

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[12] This surplus can be credited to the recent adoption of rice-manioc intercropping, which evens out manioc production throughout the year, as previously, manioc was only planted in October, following burning of the fields.

In light of the nutritional situation in some of the villages, the Health Subprogram's food supplement for children under three and pregnant and lactating women is an important factor in maintaining a healthy population. However, it has the negative effect of removing the responsibility of heads of households in maintaining an adequate food supply in their homes, thus permitting a greater emphasis on commercial agriculture. The food supplement, in this manner, represents a cushion of a minimum food supply, regardless of the direction of agricultural production.

Discussion

Despite the apparent correlation between increased commercial production and lowered nutritional status, other cultural, social, and environmental factors cannot be disregarded as to their influence on the availability of foods in the villages. Examples of these factors are the availability of game, which can vary according to the length of time which a village has occupied a given site, the abundance or scarcity of fish in nearby rivers, and the age structure of the village, which influences the availability of labor, among others. Thus, malnutrition cannot be attributed entirely to the engagement in commercial activities, but must be considered within a set of factors which include the effects of sedentarization and the abandonment of a nomadic lifestyle. Although a comparison can be made between villages with regard to their level of involvement in commercial activities and its effect on village nutrition, each village has its particular history and composition of personalities. Within this history, one must also consider the cultural impacts of contact with surrounding society, with its mortality, transferences, and upheaval of subsistence activities. In addition, past paternalistic treatment of the Parakanã created an ethic of consumption among the leaders, and at times they seek to reproduce this experience by selling all their agricultural production, to the detriment of household subsistence. To the degree that village leaders influence the choice of commercial activities, their aspirations directly affect the availability and type of foods for their village. In 1998, the privileges given to commercial production could be observed in the fields at Paranowaona village, with a larger area being planted to rice, a commercial crop, and a lesser area to manioc. The rice field received more care in cleaning after the burn, and also in later weedings. The adherence to a status of consumption may lead men to sell a bunch of bananas for less than R$ 1, and use this money to buy 10 small rolls of bread or a package of biscuits, even though from a nutritional point of view this is an unequal trade.

With the sale of Brazil nuts and the introduction of commercial cropping, initiated by FUNAI and with the continuing support of the Programa Parakanã, through production inputs and transportation for harvests, it can be said that the Parakanã are well integrated into the regional economy. However, a deeper analysis shows that this integration caused a loss in their nutritional or subsistence autonomy. Despite advances in commercial production, the Parakanã, and principally women and young children, are still dependent on the provision of a food supplement. Adult males have received the greatest benefit from this agricultural "development," with women and children being left out. The most serious situation of ill-distributed resources occurs in the village which had the greatest commercial income in 1998. The conclusion from this is that for the Parakanã, integration in the regional economy has not been synonymous with an improvement in community well-being. In displacing productive efforts from subsistence to commercial crops, the preoccupation with sales has exacerbated cultural factors which privilege men to the detriment of women and children.

While the Programa Parakanã could be criticized for the effect which its support for commercial activities has had on village nutrition, the form in which this support is carried out has meant that a more serious problem has been avoided. As the Parakanã make the transition from a non-monetary society to full participation in a monetary economy, they are now at a critical point in the evolution of their relations with surrounding society. In a number of tribes, this moment has been characterized by social upheavals, in which there is the loss of prestige on the part of older adults, with control passing to those with greater facility for communicating in Portuguese, generally the younger generation. In many cases, this social transition is fueled by outsiders who have an interest in natural resources such as timber or minerals, and can result in grave distortions and threats to the social fabric of the community. In the case of the Parakanã, this social upheaval has been avoided to a large extent by providing all households with equal access to income-generating activities, regardless of their ability to speak Portuguese. While male members of younger generations accompany the sales of such products in order to make a record of transactions, this in fact serves to make distribution of revenues more equitable by reducing the concentration of financial affairs in the hands of the present leaders. The Programa Parakanã has also braked attempts by loggers to buy timber from the Parakanã. The principal species coveted by loggers is mahogany, which has been logged out in the region but still is reasonably frequent in the Parakanã Reserve. If this sort of activity were allowed, the sheer value of the transactions would result in social distortions on a scale of magnitude much greater than that observed at the moment, in the sale of extractive and agricultural products. In March 2000, while the Parakanã were at a soccer game nearby their reserve, loggers offered R$ 300 to Xawatirona, leader of Itaygo'a village, as a down payment for access to mahogany. He refused the money, although at that time he had sold his Brazil nut harvest and had more than that amount in a savings account. Perhaps his behavior might have been different at another time of year.

Conclusions

The identification of distortions in the internal equilibrium of a community, resulting from contact with external factors, is the first step for the adoption of mitigating measures. As responsible for the well-being of the Parakanã, the Programa Parakanã has tried to balance their relation of consumption and production with surrounding society. The incentives and support which the Parakanã Program provides for agricultural and extractive activities play a vital role in the maintenance and social equilibrium of the community and balance the temptations towards rapid liquidation of natural resources such as timber. At the moment, the greatest challenge for the Programa Parakanã is to find the way to convince the community of the need to equilibrate commercial production and production for domestic consumption. Measures such as the installation of açaí processing equipment to encourage village consumption and convincing village leaders to keep a small portion of the Brazil nut harvest as a school snack are steps in this direction. Support for planting of fruit trees around villages should also bring positive effects on medium-term basis. The Programa Parakanã also has given clear support for the establishment of new villages, in recognition that the occupation of new territory can result in an improved food supply.

For indigenous communities, agricultural or agroforestry extension is not an isolated element which can be separated out from other support such as health and education. Aid programs for indigenous communities, and specifically in the area of agricultural extension, must bear in mind that seemingly positive, or even innocuous actions, can cause distortions in the social fabric of a community, with unforeseen side effects. The Parakanã example shows that where inequalities exist within a community, apparently neutral interventions (such as providing support for the sale of agricultural and extractive products) may have the undesirable result of exacerbating such differences. Aid programs such as the Programa Parakanã should be aware of this possibility and actively work to resolve such inequalities.

CHAPTER 8
THE POTENTIAL FOR AGROFORESTRY IN THE TRANSAMAZON HIGHWAY REGION

Frontier Expansion in the Transamazon Highway Region

The term "frontier" can have a number of connotations, but for our purposes, we can consider it to mean the expansion of a national political and economic system into a sparsely populated region. The policies, history, and social groups involved as driving forces of frontiers in Amazonia are discussed in depth by Schmink and Wood (1984; 1992). As an area which is actively receiving migrant settlers from other parts of Brazil, the area encompassed by the Transamazon Highway and its side roads can be considered an agricultural frontier.

The construction of the Transamazon Highway in the 1970s and associated colonization projects in Pará attracted a great deal of public attention. From a geopolitical point of view, the Transamazon Highway represented Brazil's occupation of a wilderness and the incorporation of a hinterland into the national economy, and at the same time, the transfer of land tenure problems from other regions (Smith,1982; Moran,1984). For environmentalists, the highway represented the forces of capitalism tearing asunder a region with a delicate ecology and the destruction of tropical forests and Indian communities (Davis,1980; Goodland and Irwin, 1975). However, in examining the transformations which southern Pará has undergone in the last decades, the

Transamazon Highway cannot be considered alone. The construction of other large infrastructure projects also caused considerable impact in the region. The Tucuruí Hydroelectric Dam on the Tocantins River not only flooded the lands of colonists and the Parakanã Indians but also required that the Transamazon Highway be rerouted over 140 km. The development of the Greater Carajás mining project, which involved the construction of 890 km of railroad from the seaport of Itaquí, in Maranhão, to Carajás, passing through the town of Marabá, also effected considerable change in the region (de Lima, 1992; Browder and Godfrey, 1997). The discovery of gold in the numerous *garimpos* of the region brought a further influx of newcomers to the region. Many newcomers also arrived as settlers, having migrated from states in other regions of Brazil, in search of land to call their own. However, farmers who establish themselves in the region face a number of hardships, such as lack of access to transportation, health care, education, and technical assistance (Walker et al., 1997). Under these socioeconomic circumstances, the form of land use most commonly practiced by settlers is slash-and-burn agriculture followed by the establishment of pasture. This situation, and its larger implications, are discussed in more detail in the following section.

Land-Use Choices by Settlers and the Expansion of Cattle Ranching on Agricultural Frontiers in Amazonia

Establishment of pasture for cattle ranching continues to be the principal cause of deforestation in the agricultural frontiers of the Brazilian Amazon. Although government subsidies for large-scale cattle ranching have ceased, deforestation continues, with a sizeable portion credited to agricultural colonists who establish pasture following a cycle of annual cropping. This land cover transformation of forest to pasture often becomes part of a larger economic process, in which settlers sell their lots to neighbors who consolidate holdings into ranches. This process in which settlers obtain lots from the government, conduct subsistence and commercial agriculture, establish pasture, and lastly, sell off their lots to ranchers who are consolidating their holdings, and then move on to new agricultural frontiers has been termed "cattleization" [13] (Fujisaka et al., 1996).

Studies carried out on the agricultural frontiers of Amazonia have indicated two principal motives which lead settlers in agricultural colonization projects to choose pasture as a land use. One motive is that cattle can serve as a readily cashed "savings account" - besides being able to walk themselves to market, they can be sold at any time of year. According to Araújo (1997), besides their utility in supplying milk and manure, cattle on small farms in Acre are an important source of cash in emergency situations, such as when family members fall ill and it becomes necessary to purchase medicine, or to buy food when crops fail. Cattle also represent a form of storage of wealth unaffected by inflation, which was a very important consideration before Brazil's economic stabilization in 1995. A second motive is that the establishment of pasture and other infrastructure for cattle such as fences and corrals increases the resale value of a farmer's lot. In this manner, a farmer is able to transform labor into capital when he sells his lot to a rancher. In a study of two government-sponsored colonization projects in the states of Acre and Rondonia (Pedro Peixoto and Theobroma, respectively), Fujisaka et al. (1996)

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[13] This term is apparently a translation of "pecuarização," a Brazilian neologism.

found that most settlers owned cattle and had deforested approximately 40% of their parcels. More than half of the area deforested had been converted to pasture. Although only about a quarter of the farmers reported using their cattle as sources of cash income, the vast majority perceived that the overall value of their land had risen as a result of establishing pasture, fencing and corrals. According to these authors, when local ranchers or urban-based speculators purchased colonists' parcels to expand their ranches or create new ones, payments were much higher for cleared portions than for forested areas. Many instances were noted where settlers had planted pasture but did not own any cattle.[14]

Two contrasting images arise from the literature, one an almost idyllic image of the farm household which balances cropping with animal husbandry, raising chickens and pigs for home consumption and sale, and a few cows for milk and eventual sale. The other is that of the settler as an itinerant land clearer, who is only too ready to sell his lot to a rancher and move deeper into the jungle frontier. The most likely reality is that there is the truth in both these images, as well as a broad range of behaviors in between, which are influenced by a number of factors, including a settler's previous experience and skills, number and age of family members, and the availability of capital. In turn, there is an interplay of these factors with the broader social, political and economic driving forces which influence the frontier.

Considering that settlers generally have very little capital to invest in their properties, they do not have a great number of choices before them, and are in fact choosing the option that imposes the least hardship or cost to them. Following a cropping cycle, sowing grass seed to establish pasture is by far the cheapest way of maintaining deforested land under some form of use. Clumps of Amazon quicuio grass (*Brachiaria humidicola*) for propagation may even be obtained at no cost, other than the labor involved, from existing pastures or neighbors. Planting perennial crops, in contrast, generally involves sizeable investments in capital and labor, and agricultural credit for planting is not reliable. According to a CEPLAC official in Novo Repartimento, in the the 1997-98 planting season a number of farmers prepared areas for planting cacao, under CEPLAC's supervision, only to have the bank refuse financing. Agricultural credit loans may also be delayed, with the result that they are released well after the optimum planting season or in the wrong season.

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[14] Although in such cases, farmers may intend to rent pasture to others (Walker et al., 1997; Castellanet et al., 1998 and pers. obs).

While economic factors can explain in part the choices which a farmer makes concerning pasture as a land-use, a final factor which may weigh on a settler's decision to sell a lot and try his luck elsewhere is purely physical or practical, namely, the distance from his house to his fields.[15] Settlers begin occupation of a lot by felling the forest and planting subsistence and commercial crops and in sequence, pasture. Each year, a farmer may transform several hectares of forest in this manner, and eventually, as the portion of the lot nearest the road is transformed into pasture, forested areas where slash-and-burn agriculture can be carried out become increasingly distant from the farmer's house, which is usually by the roadside. INCRA[16] surveyors generally lay out lots that are in the shape of narrow rectangles, so that all lots have access to both a road and a stream. As new fields move further away from the road and the house, transportation of crops to the roadside for both subsistence and sale becomes increasingly onerous unless the farmer has a beast of burden or motor vehicle. As a result of choosing pasture as a land-use, settlers become tied to a process which ends up making it increasingly difficult for them to carry out cropping as their main source of income. Even subsistence farming becomes more difficult if they have to carry products such as bunches of bananas or sacks of rice, to give examples, one kilometer or more to their house. Rather than the passing of time being equated with the improvement of living conditions on a given property, the inverse is often true - the longer a settler lives on his lot and practices agriculture, the more difficult it becomes for him to maintain his lifestyle as a farmer. At a certain point, when a good portion of the lot has been turned into pasture, the farmer's day-to-day existence becomes easier if he moves to another location where he can establish himself nearby forest and carry out slash-and-burn agriculture. In a sort of perverse irony, cattle, who can transport themselves by walking, end up occupying the most easily accessible roadside locations while crop production moves further and further away.

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[15] This observation was made during visits to farms neighboring the Parakanã reserve.

[16] The National Institute for Colonization and Agrarian Reform

Impacts of the current land-use model

The process of "cattleization" can be regarded as detrimental from social, economic and environmental standpoints. From the social standpoint, it entails hardships for settlers who pick up and periodically move to locations further away from necessary services such as transportation, health, education, and agricultural extension services.

From the economic viewpoint, it represents the misdirection of government investments in roads and colonization projects, which are supposedly to benefit small-scale farmers but end up as subsidies for cattle ranchers, who often compose regional elites. Walker et al. (1997) point out that an inversion of expected land-use patterns occurs near towns and cities in Amazonia: rather than finding intensive agriculture in these locations, what one finds are cattle ranches. Small-scale farmers are to be found on the edge of the frontier, with its attendant problems of lack of transportation for crops and lack of health and education services. On strictly economic terms, cattle ranching generates a lower economic return per hectare, when compared to other land-uses (Yamada, 1999). From the ecological point of view, ranching implies in the large-scale transformation of ecosystems with ensuing impacts on biodiversity, soil properties, and local and regional hydrological cycles and climate (Prance and Elias, 1982; Climatic Change, 1991). The continued expansion of pasture in otherwise forested regions, which have been made fire-prone by logging activities, increases the risk of forest fires, with both ecological and economic impacts (Uhl and Buschbacher, 1985). Escaped pasture fires can destroy not only perennial plantation crops, but also cause ground fires which spread through the forest. Besides killing the natural regeneration of timber species, such fires have an impact on settlers, as they destroy resources such as aroids used for fibers in crafts and house construction, as well as pole-sized trees, also important for house construction and roofing (Nepstad, et al., 1999; K. Carvalheiro, pers. com., 2000).

For small-scale farmers, land-use decisions favoring establishment of pasture are practically irreversible, when compared to traditional slash-and-burn/fallow systems.

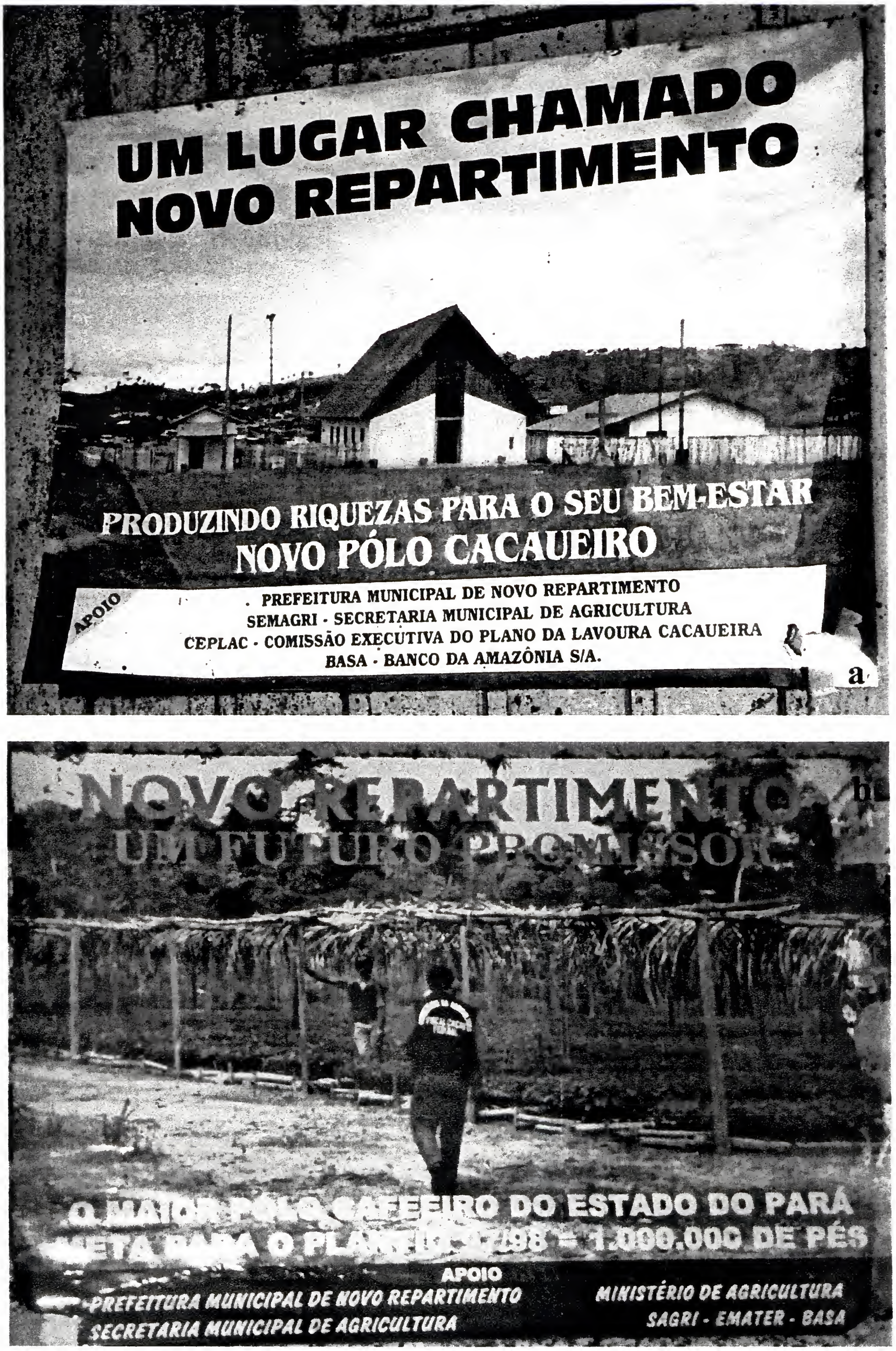
Once pasture is in place, it becomes difficult to establish trees. As grasses are aggressive competitors and are fire-prone, pasture can only be converted to other uses with significant capital or labor investments. Traditional systems offer a greater variety of land-use options: forest fallow can be followed by annual cropping, perennial crops, as well as pasture. The effect of pasture establishment, in contrast, is to decrease the availability of suitable areas for carrying out subsistence and commercial cropping.

The Potential Role of Agroforestry

For the small-scale farmer, the form of land use currently practiced in the Transamazon Region is unsustainable, if we take as evidence the turnover in property ownership. Forms of land-use employing agroforestry systems could, however, help to change this situation. It is widely accepted that agroforestry can help to optimize land use in the tropics (Nair, 1993), and in a survey of 122 households along the Transamazon Highway, Walker et al. (1997) found that the presence of perennial crops made a significant difference in household income and stability. Unfortunately, the cultivation of perennial crops occupies only a small portion of the acreage of land being converted from forest in the Transamazon Region. Nevertheless, agroforestry as a more sustainable form of land occupation is attracting increasing attention on all levels, from the small farm to the federal government. In 1998, for example, the municipal government of Novo Repartimento launched an ambitious program for planting coffee and combinations of cacao, peach palm, and timber trees, as well as assorted fruit trees such as cupuaçu and soursop (Fig. 8-1). Also in 1998, the Minister of Land Tenure Policy, Raul Jungmann, announced a package of measures which would create a "Green Agrarian Reform." This program was to finance agroforestry, recuperation of degraded areas and sustainable forest management for small and medium scale landowners and community associations (O Liberal, 1998; Diário do Pará, 1998). Around this time a number of agroforestry projects began to receive financing through the Ministry of Environment's Environmental Demonstration Projects Program (PDA), which channels funds from foreign donors such as Germany, the European Union, the Rain Forest Trust Fund, and the United Nations Program for Development (PDA Informa, 1998). In 1999, the state government of Pará sought federal funding for a proposal which would entail the planting of 100,000 ha/yr, over 25 years, of "economic forests" consisting of oil palm, peach palm, and timber species. This proposal was referred to the National Bank for Economic and Social Development (BNDES) by Celso Lafer, Minister of Industry, Commerce and Development, (O Liberal, 1999). At least on a policy level, therefore, the state government of Pará has shown a commitment towards reducing deforestation and investing in agroforestry (Fig. 8-2). Whether this will actually have an effect on the status-quo remains to be seen.

Future sources of funding for agroforestry: carbon sequestration?

In the future, sources of funding for agroforestry initiatives may arise from concerns over climate change and the need to mitigate greenhouse gas emissions. Up until now, however, carbon sequestration projects involving the purchase of CO2 offsets have generally been associated with large, discrete blocks of land where some form of tree plantation or forest conservation is carried out. While agroforestry as a land use


UM LUGAR CHAMADO
NOVO REPARTIMENTO
PRODUZINDO RIQUEZAS PARA O SEU BEM-ESTAR
NOVO PÓLO CACAUEIRO
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SEMAGRI - SECRETARIA MUNICIPAL DE AGRICULTURA
CEPLAC - COMISSÃO EXECUTIVA DO PLANO DA LAVOURA CACAUEIRA
BASA - BANCO DA AMAZÔNIA S/A.
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UM FUTURO PROMISSOR
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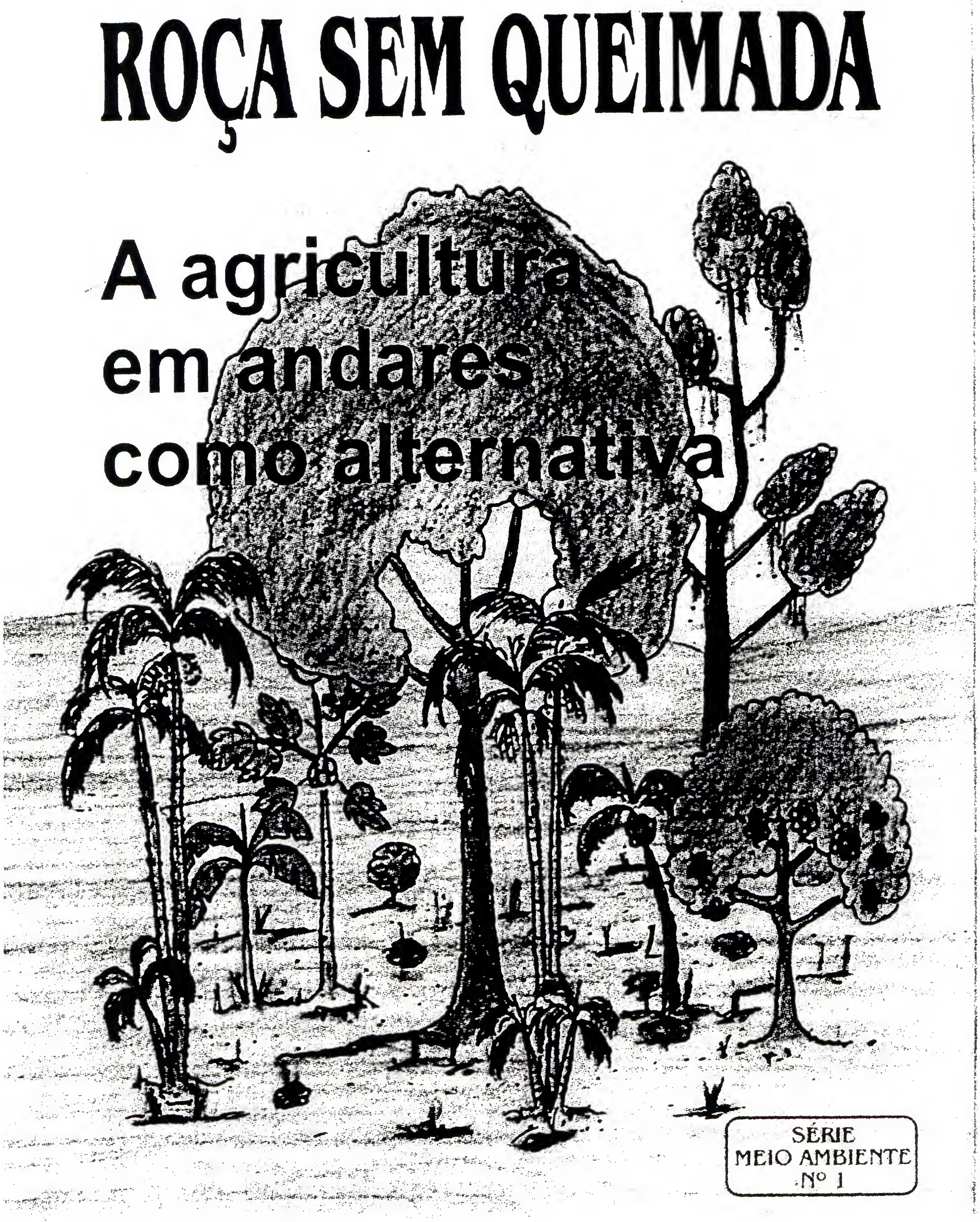
MINISTÉRIO DE AGRICULTURA
SAGRI - EMATER - BASA

Figure 8-1: Posters illustrating projects for cacao and coffee in the Municipality of Novo Repartimento (Pará). Posters read: (a) *A place called Novo Repartimento - Producing riches for your well-being - New cacao-growing center* and (b) *Novo Repartimento - A promising future - The largest coffee-growing center of Pará - Goal for 97/98 planting season = 1,000,000 trees*



ROÇA SEM QUEIMADA

A agricultura
em andares
como alternativa

SÉRIE
MEIO AMBIENTE
Nº 1

Figure 8-2: Cover of a primer produced by the State Secretariat of Science, Technology and Environment (SECTAM) of Pará, entitled: *Plantations without burning: Agriculture in storeys as an alternative*

stores more carbon than pasture (Fujisaka et al., 1998), involving a number of small landowners in a carbon sequestration project poses serious logistical problems in terms of monitoring project performance and compliance to guidelines. A piecemeal approach using available GPS/GIS[17] technology for monitoring individual properties and fields is certainly possible, but would most likely be prohibitively expensive. Perhaps the role of agroforestry in carbon sequestration would be better explored through binational aid projects with less rigorous demands with regards to quantifying results. A mix of policies and actions which brings together local and regional interests (such as income generation, household food security, conservation of non-timber forest products), national interests (forest conservation and environmental quality, sustainable development) and global interests (biodiversity conservation, climate amelioration) could work towards the same general goals. Nevertheless, agroforestry extension activities should be able to provide a rigorous accounting of their results. Trees, after all, are tangible objects and can be counted. More information is also needed concerning household-level decision making if the role of agroforestry in reducing deforestation is to be firmly demonstrated.

Considerations on Potential Agroforestry Systems and their Components

For most frontier farmers in Amazonia, the supply of trees is not a problem. Nearby forests have plentiful supplies of wood for fuel, construction, fence posts, and other uses. Trees planted along with crops, however, will compete for farmers' labor. Nobre (1998) reports that in Acre the additional demands of agroforestry activities overburden farmers, and have required communities to organize to share labor for cleaning fields, harvesting crops and producing tree seedlings. For settlers to plant trees, especially if the same species exist in the forest, there must be compelling reasons. In the case of species such as cupuaçu and Brazil nut, planting at greater densities than that of the naturally occurring trees would greatly increase the production of these items on a settler's lot. Theft of fruit, which has been reported for both these species, would be reduced by having trees growing closer to homes.

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[17] GPS - Global Positioning System; GIS - Geographic Information System

Settlers in the Transamazon Region have shown much interest in planting perennial crops such as cacao, coffee and black pepper (Castellanet et al., 1998). However, investments in these commodity crops may be insufficient to provide a stable income base, given the vagaries of the world economy and the possibility of disease problems. Financial modeling of several agroforestry systems for Rondônia found that the most profitable system, a cupuaçu/freijó[18] /black pepper intercrop, showed a dramatically reduced performance if pepper prices fell 10%, which is certainly a plausible possibility (Vosti et al., 1998). From the economic and ecological viewpoint, more sustainable systems would require more species, and possibly interactions with an animal component. As Walker et al. (1997) point out, if the 30,000 ha of cacao established along the Transamazon had been planted with economically valuable shade trees such as rubber or timber species, today the landowners would be enjoying the benefits of a greater number of economic options.

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[18] *Cordia alliodora*, a timber tree

With labor a limiting constraint for frontier farmers, trees to be planted in agroforestry systems should either be fast growing, in order to outcompete secondary vegetation, or shade tolerant. In experiments at INPA, in Manaus, various important timber species exhibited better initial growth under shade conditions. For jacareúba (*Calophyllum angulare* A.C. Smith) seedlings, 70% shade resulted in better height and leaf area growth, while for angelim-pedra (*Dinizia excelsa* Ducke), better growth (in height, collar diameter, and dry weight) was obtained at 30% and 50% shade (Muroya et al., 1997; Varela and dos Santos, 1992). Shaded conditions for initial growth can also contribute to improved bole form. For more open agroforestry systems, different intercrops could be used, such as non-twining sweet potato varieties. These would be valuable adjuncts as ground covers, and could also provide feed for farm animals such as pigs and chickens.

Various researchers have shown that cupuaçu, peach palm and Brazil nut combinations can comprise successful agroforestry systems, able to remain productive with low levels of inputs (McGrath, 1998; Sousa et al., 1999). If posters presented at the II Brazilian Agroforestry Congress (held in November 1998 in Belém) are a fair representation of current trends, it can be said that recent agroforestry research in Amazonia has tended to focus on some mixture of these three species (Embrapa, 1998). However, these species alone may not be sufficient to meet the needs of farmers, and it may be necessary to include other species in order to ensure adequate income generation, as well as to mitigate effects of "off years," for trees such as cupuaçu or Brazil nut. Based on local market preferences for juices, some of these fruit could be: soursop, mombin, murici, acerola, bacurí, and guava. Other species which could gain market acceptance include araçá-boi. However, all of these are perishable fruit, which would pose a serious problem for marketing, given the lack of reliable transportation. These species most likely would require different configurations of agroforestry systems, as they have varying demands in terms of light and nutrients. In the agroforestry experiment conducted with the Parakanã, for example, coconut and soursop performed very poorly in a field-fallow situation. Further fine-tuning of tree combinations will need to be investigated. In an experiment conducted in Rondônia, for example, Souza et al. (1998) found that cupuaçu production was reduced 39% and 50%, respectively, when associated with freijó and peach palm, in comparison to intercropping with Brazil nut. They attributed this reduction in cupuaçu production to the greater export of nutrients in peach palm fruits and to greater immobilization of nutrients by freijó, in comparison to Brazil nut. The effect of trees on annual crops should also be further investigated, not only with regard to competition for light, nutrients and water, but also in terms of positive or negative effects on pest populations. Fazolin and Estrela (1999), for example, found that peach palm and açaí planted in an agroforestry system in Acre sheltered the main pests attacking crops such as beans, maize, and rice.

Even with adequate extension services and support for tree planting, a total change-over to agroforestry systems is unrealistic, as frontier farmers will still need to produce staple crops for household consumption. Rather, slash-and-burn fields should be seen as starting points for agroforestry in the same way that today they are starting points for pasture establishment. It is also unrealistic to exclude pasture from the options available to farmers. Rather, forms of intensifying pasture use should be investigated, such as the use of silvopastoral systems or legume forage banks. Even where a less intensive form of land use is practiced, such as in extractive reserves for rubber tappers, pastures for grazing mules (as well as sheep and cattle) can be an important component of the system. Mules are necessary to transport goods such as Brazil nuts and rubber from rubber tappers' holdings in the forest to regional markets, and, as was seen for the Parakanã, from the forest to a roadside. As pointed out by Kainer (1997), although it may appear counterintuitive, such pastures may be critical components of a forest conservation strategy, in that they permit the marketing of extractive products.

Near urban centers in Amazonia, especially capital cities, more intensive forms of ranching involving mixed dairy/beef breeds ("gir-holanda") have arisen to meet growing demands for milk products (Serrão, 1992). These operations generally utilize feeding of supplements, and the use of legume forage trees as an alternative feed could be useful in these situations. Besides having a higher protein content, generally around 20%, legume trees have deeper roots than pasture grasses and remain greener for a longer period of time in the dry season. The ability to provide fodder with a high crude protein content during the dry season, when crude protein levels in grasses may fall below 7%, considered a critical level for digestibility, would help to maintain milk production.

Contributions of Research Institutions and Binational Aid to Agroforestry Development

Most of the major agroforestry research efforts in Brazilian Amazonia have been the result of binational cooperation. The lines of research often reflect pre-established agendas of foreign scientists and their funding bodies. This does not necessarily imply the substitution of local agendas, but rather, the lack of such agendas. At the same time, it has generally been expected or assumed that the diffusion of research results would be taken care of by the host institution. Unfortunately, a number of factors keep this from happening effectively. Among these factors may be the lack of a critical mass of researchers, a weak institutional will or culture geared towards generating extension-oriented products, and the lack of continuity in research, necessary to produce long-term results. This last item may be exacerbated by the difficulty in establishing and carrying out complex agroforestry experiments.

There are, however, exceptions to the situation described above. The work being done at the Instituto Nacional de Pesquisas da Amazônia (INPA), in Manaus, Amazonas, for example, includes a very interesting series of on-farm experiments in the nearby municipality of Manacapuru. INPA, unfortunately, has few researchers working specifically on agroforestry. In the State of Acre, PESACRE, an NGO funded by USAID to carry out research/extension in agroforestry, has since its inception been heavily involved in training personnel in participatory methodologies. This has enabled it to evolve in the direction which best meets the needs of its clientele. However, up until now the parameters of evaluation which can gauge PESACRE's success have been mostly qualitative.

Embrapa (Empresa Brasileira de Pesquisa Agropecuária), Brazil's premier agricultural research agency, theoretically has agroforestry as the number one priority for its various regional centers in Amazonia, which were transformed from commodity centers and renamed as “agroforestry research centers” in the late 1980s. However, the lines of research at these centers are still heavily weighted towards previous interests. Many researchers continued with their particular lines of research without necessarily adopting an integrated approach which would be more typical of agroforestry systems. An examination of Embrapa’s role within a national scenario of agricultural development gives a snapshot of some of the problems and contradictions which Brazil faces today: at the same time that Embrapa is working with cutting edge technology such as transgenic plants, settlers are barely getting by on frontier farms. It has been a challenge for Embrapa to adapt its philosophy and style of research to the country’s varying needs.

Research on nitrogen-fixing legumes in agroforestry systems

Very little research has been done examining the interaction of nitrogen-fixing legumes and other crops in agroforestry systems. In the 1998 Brazilian Agroforestry Congress the few papers which looked at legumes dealt mostly with their survival, growth, and biomass production (Embrapa, 1998). Almost no research has been carried out on alley cropping in the Brazilian Amazon. Although on a global basis the results of alley cropping have been ambiguous, with positive effects on overall crop yields only occurring in certain situations, (see Sanchez, 1995, for a review), much of the research has been done with intercropped maize, which has critical periods in its growth cycle which must be matched by the availabilty of mineralized N and other nutrients. Perhaps different results might be found with manioc in alley cropping, which besides being less demanding of nutrients, has a much longer growth cycle, and thus would be more forgiving of delays or slower N mineralization from legume mulches. Given the importance of manioc as a staple crop in Amazonia, the possibility of maintaining or increasing yields through alley cropping merits greater attention.

The German-funded SHIFT project at Embrapa-Manaus has used the legume vine *Pueraria phaseoloides* as a cover crop and nitrogen source in agroforestry trials. However, *Pueraria* is very labor-demanding, requiring constant maintenance to keep it from entwining and covering the trees. As discussed by McGrath (1998), legume vines are probably not a realistic option for small-scale farmers who have time and labor constraints.

A positive trend in research has been an increasing number of studies which include the ice-cream bean (*Inga edulis*), a native species well-accepted by farmers. It nodulates easily and the fruit are appreciated by children, cattle eat the empty pods and leaves with relish, the wood is good for fuel, and game animals such as agoutis eat the seeds.

Discussion

In any particular location in Amazonia, the types of agroforestry systems employed by small-scale farmers will be very dependent on various factors such as land-use history, and access and proximity to markets. A study of small farms near Capitão Poço, Pará, by Vilar (1998), exemplifies the situation on what could be described as an old, stabilized frontier, with reasonable access to the urban markets of the capital, Belém. Farmers were found to be engaged in an active and dynamic process of search for new production systems, new crops, and new combinations of crops. In response to drops in prices of field crops, in the early 1980s they began to shift to banana and black pepper. However, prices of these products fell in the late 1980s, so farmers began to invest in plantations of orange, passion fruit and acerola or Barbados cherry (*Malpighia emarginata*), with positive results in the early 1990s. However, in 1999, orange prices were very low (sacks with 100 oranges were being sold at roadside stands for R$ 3-4), and acerola has since become the cheapest of the frozen fruit pulps. It remains to be seen how farmers will adapt their choice of crops and farming systems to such falling prices.

Distance or proximity to a regional market may have an enormous influence on the profitability of an agroforestry system. Often, the most valuable products are also the most perishable, and can not be easily transported over long distances on bad roads. Even for farmers who wish to plant the less perishable perennial crops, labor constraints and lack of access to credit may put a damper on investments in agroforestry. It may be possible for settlers living on an agricultural frontier, with access to forest, to rely more on forest products as part of their livelihood strategies. Alternatively, there is the possibility that agroforestry systems may be able to incorporate species which are presently exploited in the wild. This is already the case for cupuaçu, which is increasingly planted as a component of agroforestry systems in Amazonia. These possibilities are not limited to fruits, but may include plants which serve as raw materials for pharmaceutical products. Jaborandi (*Pilocarpus jaborandi*), for example, changed from a strictly wild-gathered commodity to the object of large scale plantings by Merck in the state of Maranhão. Technical improvements in the cultivation, harvesting and processing, of non-timber forest products, which has been termed "neo-extractivism" by Rego (1999) may provide alternatives to an agriculture dependent on annual crops. In the future, timber species may have a much more important role in agroforestry systems in Amazonia, but at the moment, forest resources are not a limiting factor, so there is little economic incentive to plant trees for sawtimber. In any case, whether farmers choose to invest in the conventional perennial crops, or explore new ones, some kind of agroforestry system will be involved.

According to Wigold Schaffer,[19] coordinator of the Brazilian Ministry of Environment's "Environmental Demonstration Projects"(PDA), financed by the G-7 countries, the initial evaluation of agroforestry systems funded by the PDA found that the majority did not meet the goal of increasing household income, but rather, have been utilized mostly as a form of home garden or orchard. Neither has there been an integration with other production activities carried out on the farms. Nevertheless, these systems did contribute, in many cases, to household food security. If effective systems were available to farmers, it is likely that they would be adopted, despite the hardships of frontier living. Without any extension efforts on the part of the government, colonists have clearly come to dominate the technology of pasture grass establishment and are very quick to utilize new varieties. An example is "brizantão" grass (*Brachiaria brizantha*) which rapidly became the pasture of choice.

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[19] Presentation given at the Third Brazilian Agroforestry Congress, November 24, 2000 in Manaus, Amazonas.

Conclusions

The predominant form of land use practiced by small-scale farmers in the Transamazon Region has as its end point the conversion of forest cover to pasture, which causes impacts on biodiversity, climate, and watersheds. For the small-scale farmer, the present system is not sustainable, if we take as evidence the turnover in property ownership. Research in the Transamazon Highway region has found that perennial crops make a significant difference on household income and stability. Sequential agroforestry systems with fruit or other trees integrated into a cropping system of annuals or semi-annuals are a viable means of establishing permanent crops in farmers' fields, and they have a long tradition of use in Amazonia. However, the reality of small-scale farmers, especially in frontier regions, results in a number of constraints to the adoption of such systems. As a result, the cultivation of perennial crops, suggested as a more sustainable form of land occupation than pasture, represents only a small portion of the acreage of land being converted from forest in the Transamazon Region. From social, political, and economic viewpoints, prohibiting farmers from establishing pasture on their properties would be very difficult. More effective would be to ensure that agroforestry extension and investment capital is available at the moment that they are making land-use decisions regarding their first fields. Efforts to increase the percentage of farmers employing perennials must also be concerned with the further identification of economically and ecologically viable systems, and the participation of farmers in defining goals for research/extension. Finally, establishing methods for the control and prevention of fires will be necessary to reduce the risk of farmers losing their investments in perennial crops.

CHAPTER 9
SYNTHESIS AND CONCLUSION

Introduction

There are many stories to be told about Amazonia, even with regard to one small part of the region. These are the stories of the indigenous peoples, the first settlers and colonizers, and the recent waves of agricultural migrants and gold prospectors. One of these stories is that of the Parakanã, who in the past few decades have come from being a stone-age tribe to full participants in the monetarized economy of the region. The Parakanã originated from Tupi-speaking tribes that fled the coastal region of Brazil following colonization by Europeans in the 16th century, and who were further fragmented by diseases brought to the Tocantins Valley by missionaries and military between 1600 and 1700. At some stage the Parakanã may have lost a portion of their agricultural technologies, and in this process of "horticultural regression" they turned to a greater reliance on the gathering of wild foods such as Brazil nuts and the nuts of the babaçu palm, which are common in the region. However, some of these same products also attracted commercial interests, and in the beginning of the 20th century the Tocantins Valley became an extractive frontier for collectors of Brazil nuts, rubber, and balata gum, as well as hunters of animal skins. Although the construction of the Tocantins Railroad, built to transport such products, led to occasional contacts with outsiders, the Parakanã remained relatively isolated until the 1970s, when the Transamazon Highway cut through the middle of their traditional territory. Contact by the Indian agency and resettlement had disastrous effects on the Parakanã, and an estimated 50% of the population died of introduced diseases in the following years. Further infrastructure development in the region, in particular the Tucuruí Dam (finished in 1984) caused additional impacts on the Parakanã, who were once again forced to move, this time because their lands were to be flooded. An initial attempt to mitigate the social and ecological impacts of Tucuruí on the Parakanã, funded by Eletronorte, the regional power company, failed due to the mismanagement of funds. However, in 1987, a second such program, also funded by Eletronorte, was established on a firmer basis. This initiative, the Programa Parakanã, has had success in maintaining the health of the Parakanã and the integrity of their reserve, as well as providing education and support for agricultural and extractive production. As a result, the Parakanã have entered a new phase of relations with surrounding society, in which the principal vector of change has been their participation in the regional economy. Once limited to bartering or selling forest products such as Brazil nuts, today the Parakanã exploit a number of extractive and agricultural products and are actively engaged in the market economy.

For the Parakanã, and those who work with them, these are very exciting times, as the road to economic autonomy presents both dangers and opportunities. It is within this context that research was carried out, and the transition from a non-monetary to a monetary economy forms a backdrop for some of the topics in this dissertation. After introductory chapters on the question of economic relationships between indigenous communities and Brazilian society (Chapter 2), the history of agroforestry traditions in Amazonia (Chapter 3), and the ethnohistory of the Parakanã (Chapter 4), the main body of research can be divided into two distinct parts. The first part (Chapter 5) considers the role of agricultural and extractive forest products in the Parakanã economy, using exploratory or ethnographic research methods. In providing data on the Parakanã's lifestyle and economy, this research created a necessary background into which the second part of the research fits. This second part (Chapter 6) consists of an agroforestry research/extension experiment with the Parakanã. These two parts of the dissertation will be summarized separately below, followed by a brief section synthesizing the overall results and findings.

Extractive Forest Products in the Parakanã Economy

Non-timber forest products (NTFPs) have attracted the atention of researchers, conservationists, and policy-makers interested in providing economic alternatives to deforestation. Ascribing monetary values to NTFPs produced by forest dwellers is one form of attaching an economic value to forest conservation, whose other benefits such as biodiversity conservation, climate stabilization and carbon sequestration are difficult to quantify, and are often regarded as intangible. NTFPs have provided the justification for setting aside large areas of forest for extractive reserves for rubber tappers in Acre and may positively affect perceptions about creating reserves for indigenous communities, to the extent that it can be shown that such communities may be able to live traditional lifestyles and still contribute to regional economies. As a contribution to this discussion of the role of NTFPs and forest conservation, the first part of the research looked at how NTFPs fit into the Parakanã's economy and lifestyle.

Data collected from May 1998 to December 2000 on the products which left the villages to be sold show that NTFPs are a very important component of the Parakanã economy. However, there are important differences between villages in terms of the choice of products, principally due to factors such as the access to reliable transportation and perishability of the products. For some villages, generally those closer to the Transamazon Highway, extractive forest products were on approximately equal footing with agricultural products, although this ratio varied from year to year due to the variability in NTFP harvests. For villages further away from roads, and unable to sell more perishable products such as bananas or açaí, non-perishables such as Brazil nuts contribute a greater percentage of revenues.

The observations on the Parakanã economy provide insights on the results of integrating indigenous communities into market economies. In the case of the Parakanã, it was found that greater participation in markets led to inequality of resource distribution between genders. Women participate in harvesting of almost all products, yet have no say in how revenues are spent, and in some villages, products which were traditionally part of the diet may now be reserved for sale. Although these are probably not the sole responsible factors, the village with greatest revenues also had the worst nutritional status among women and children. One conclusion to be gathered from the case of the Parakanã is that for indigenous communities, increased integration with local and regional economies is not necessarily synonymous with improved well-being.

Agroforestry Research/Extension with the Parakanã

The invitation to work with the Parakanã and develop an agroforestry research/extension project meant that academic research objectives had to be balanced with extension objectives. The initial extension objectives were twofold: (1) explore the cultivation of fruit trees as a new source of income, diversifying agricultural production and stabilizing cash flows for villages, and (2) increase fruit production for community consumption to alleviate nutritional problems, particularly in women and children. Within these extension goals, it was possible to identify several research objectives or lines of inquiry, namely (1) testing home gardens as a technology for agroforestry extension, and (2) exploring the potential for integrating commercial tree crops in slash-and-burn agriculture systems. Key elements in this second question concerned the socioeconomic and biological constraints to expanding fruit tree home garden systems towards more commercial production. Fruit tree home gardens are the most common agroforestry systems in Amazonia and represent a tried and true agroforestry technology. However, home gardens generally are subsistence-oriented, and occupy locations around houses that are more likely to receive greater care, as well as greater nutrient inputs from human and animal wastes. As such, an important question is whether they can be expanded for commercial production and provide viable economic alternatives for small-scale farmers.

Four species of fruit trees, chosen to represent a range of ecological requirements as well as different products, were used in experimental agroforestry plantings: cashew (*Anacardium occidentale*), coconut (*Cocos nucifera*), cupuaçu (*Theobroma grandiflorum*), and soursop (*Annona muricata*). Seedlings were planted in different environments consisting of villages (around homes), maize and cassava polyculture fields, and in planting pits fertilized with locally available materials (chicken manure, ashes, bones) near a village. Additional treatments for shade tolerant cupuaçu were under adult Brazil nut trees near field edges and under new (recently planted) and old banana groves. Trees were monitored for two years following planting.

Evaluation of the agroforestry experiment found that for the Parakanã, home gardens of fruit trees are a useful technology for agroforestry extension. However, expanding from village plantings to planting in fields gave poor results. For coconut, growth and survival was much greater in the open (unshaded) environment of villages. In this environment, although growth in fertilized planting pits was not significantly greater, flowering began earlier for fertilized trees (82% of fertilized trees were flowering at 2 ½ yrs, vs. only 17% for those planted w/out fertilizer). For soursop, results for growth and flowering were similar, with 100% of trees in fertilized planting pits flowering or fruiting at 2 yrs, compared to 83% in unfertilized plantings. Although earlier work with cupuaçu seedlings resulted in almost 100% mortality for small seedlings planted in full sun, in this study, better growth was observed for seedlings planted in the unshaded village environment. Survival, however, was greater for seedlings planted in shaded environments, indicating that planting in full sun can be riskier for cupuaçu.

Nevertheless, field environments can also present certain survival risks, particularly with regard to fire. In the dry season, escaped fires used to burn fields killed cupuaçu seedlings planted under Brazil nut trees and under banana.

When compared to coconut or soursop, cupuaçu showed a more ambiguous response to shade, probably due to both leaf shedding in the dry season and plasticity in tree architecture. In open environments, cupuaçu exhibited a more erect form, with considerable self-shading, overlap of leaves. In shaded environments a greater tendency to plagiotropic (horizontal) branching and leaf display was observed, apparently for more efficient light utilization.

The results indicate that some species, such as cupuaçu, may be better suited than others to the shaded conditions in fields. Thus, agroforestry extensionists should consider the characteristics and potential of different planting locations within a single property before deciding on a choice of species.

Soil samples taken at the different planting sites indicate that higher levels of nutrients (N, P, K) are found around villages. Fields and Brazil nut plots adjacent to villages were also higher in nutrients. There was not a clear relationship between soil nutrient levels and initial tree growth, and at least under the conditions of this study, light seems to have been a more important factor. Nevertheless, increased nutrient inputs around homes may be important for maintaining long-term productivity of home gardens. Locally available fertilizer may be useful for maintaining or increasing productivity of trees planted further away from the village environment.

As to the role of agroforestry systems in the Parakanã economy, home gardens appear to be a technology with a high potential for adoption, as there was enthusiasm for planting fruit trees around homes. Care of trees planted in field environments, however, would require more labor than the Parakanã presently invest in agriculture. Although the Parakanã sell a considerable amount of agricultural products, they do not devote much time to weeding fields and generally only get one or two crops from each field. Cultural characteristics may make extractive activities such as harvesting Brazil nuts more attractive. Nevertheless, the Parakanã are not closed to new ideas: during the study period, new methods of cultivating cassava and beans were adopted, and mahogany and other seeds became a new extractive product, so only time will tell if in the future they will adopt other forms of agroforestry.

Synthesis

In an age when deforestation has become an issue of global concern, and the trend for small-scale farmers in Amazonia is "cattleization" – establishment of pasture after a short cycle of annual cropping, non-timber forest products (NTFPs) and agroforestry systems have been suggested as less destructive alternatives of land use. With regard to the question of whether NTFPs can contribute to household income for settlers in the region, the Parakanã study shows that NTFP harvests can be highly variable from year to year. In Pará, this makes it risky or impossible for households to rely on NTFPs as their sole source of income. Because gathering of extractive products fits well with a traditional lifestyle of hunting and gathering and an extensive land base, the revenue from extractive products is probably much more important to Parakanã households than it is for settlers. Nevertheless, this does not mean that the marketing of NTFPs are the exclusive domain of the Parakanã. In 2000, a year of bumper crops of Brazil nuts, middleman normally engaged in rice buying in the region were able to devote themselves to trading in Brazil nuts. On strictly economic terms, the Parakanã model of extractive-based economy is not immediately applicable to settlers, as there are hidden costs such as transportion and marketing, as well as health care, which are covered by the Programa Parakanã. For small-scale farmers, extractive products are likely to be economically viable only if included within a matrix of other productive activities.

A comparison of the Parakanã with their neighbors shows that deforestation drastically reduces the number of options available to land owners. The Parakanã villages nearby the Transamazon Highway are able to exploit their extensive stands of açaí to sell fruit to as far away as Belém, the major consumer market in the region. However, neighboring landowners with easy access to the Transamazon Highway are unable to exploit this market niche because their açaí stands are long gone, having been converted to pasture. Deforestation and damage to a resource base may occur faster than the development of mechanisms which work towards conservation, such as increased awareness of the value of NTFPs, and perhaps more importantly, the establishment of viable marketing structures. Efforts to develop NTFPs as tools for forest conservation in the Transamazon Region need to work primarily on improving transportation, processing and marketing to ensure greater profits for producers. However, there is the danger that in reducing transportation costs, improved road access will also increase logging activities, particularly of less valuable timber species, and lead to more forest conversion, unless other institutional controls are in place.

Despite the Parakanã's apparently conservationist lifestyle, temptations and pressure to liquidate resources such as timber for immediate cash is very great. Although such temptations have been restrained by the Programa Parakanã, this has only been possible by offering at the same time support for economic alternatives, in this case the marketing of agricultural and extractive products. Perhaps one of the lessons to be learned from this concerns the role of indigenous communities as conservators of forests: if this is indeed to happen, then they must have effective support for developing non-destructive economic alternatives.

With regard to the applicability of agroforestry for agricultural colonists, home gardens appear to be a viable technology for agroforestry extension and can improve household food security. However, expansion of tree plantings to slash-and-burn fields encounters a set of socioeconomic and biological constraints. Fields left to fallow are characterized by rapid growth of secondary vegetation, which will compete with planted seedlings. Labor demands for maintaining trees may compete with other farm activities. Sites away from homes are also more prone to damage from accidental or escaped fires in the dry season. Lastly, soil nutrients levels are greater around homes, and planting in fields may require use of fertilizers. However, use of locally available fertilizers such as manure and ashes may possible. These constraints must be addressed if small-scale farmers on agricultural frontiers are to be encouraged to plant more trees or explore agroforestry as an alternative to pasture establishment

APPENDIX

SOIL CHEMICAL CHARACTERISTICS FOR LOCATIONS OF EXPERIMENTAL AGROFORESTRY PLANTINGS, PARAKANÃ RESERVE, PARÁ

Plot	**Depth (cm)**	**NO$_3$**	**P (mg/kg)**	**K (mg/kg)**	**pH**	**OM (%)**
Field 1	0 - 10	3.8	22.8	62.1	6.4	1.6
	30-40	1.6	0.8	55.5	5.0	0.8
Field 2	0 - 10	3.6	4.1	28.9	5.5	1.4
	30-40	1.6	0.5	22.0	4.6	0.8
Field 4-A	0 - 10	1.4	1.6	37.1	5.4	1.4
	30-40	1.2	0.5	28.9	4.9	0.6
Field 4-B	0 - 10	1.2	2.0	17.2	5.6	1.4
	30-40	0.8	0.5	14.1	5.0	0.6

Banana 1-new	0 - 10	1.6	3.5	25.5	5.8	1.6
	30-40	2.0	0.5	34.4	4.9	0.6
Banana 2-new	0 - 10	1.6	2.1	26.6	5.6	1.6
	30-40	0.8	0.7	9.8	4.9	0.5

Brazil nut 1	**0 - 10**	**3.8**	**4.5**	**41.4**	**4.9**	**1.6**
	30-40	1.8	1.0	39.8	4.8	0.8
Brazil nut 2	0 - 10	4.4	4.6	28.4	4.8	1.8
	30-40	1.8	0.6	27.8	4.7	0.7
Brazil nut 3	0 - 10	2.8	3.4	39.6	5.0	2.1
	30-40	2.0	0.4	20.2	4.9	0.7

Village 1	**0 - 10**	**3.4**	**47.2**	**112**	**5.7**	**1.0**
	30-40	4.2	0.9	20.6	4.8	0.4
Village 1	0 - 10	3.4	8.2	39.1	6.2	0.9
(fertiliz. pits)	30-40	2.6	1.2	70.2	5.5	0.6
Village 2	0 - 5	3.8	12.2	29.9	5.6	1.7
	15	2.6	6.3	23.9	5.9	1.1
	30	1.2	3.4	11.5	5.3	0.5
	50	1.6	2.3	23.8	5.0	0.4
	80	3.8	2.7	34.0	4.9	0.2
	120	4.4	1.5	22.0	4.8	0.2

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BIOGRAPHICAL SKETCH

Robert Pritchard Miller was born on July 19, 1962, in Rio de Janeiro, Brazil. Most of his youth, however, was spent in the city of São Paulo, where he studied at the Pan-american Christian Academy, then at the American Graded School, where he graduated from high school in 1980. His university experience included two years studying botany at Duke University, North Carolina, followed by three years at the University of California, Berkeley, where he obtained a degree in forestry. Following a semester at the California College of Arts and Crafts, in Oakland, he returned to Brazil, whereupon he enrolled in the graduate program of the Instituto Nacional de Pesquisas da Amazônia (INPA) in Manaus, Amazonas, obtaining a master's degree in forest management in 1992. His thesis research was carried out on the Ilha de Maracá Ecological Station, as part of a joint project involving INPA and the Royal Geographical Society of London, England. While finishing his master's studies, he was employed by the State of Amazonas as a lecturer in forestry at the Instituto de Tecnologia da Amazônia (UTAM), where he was also involved in extension and ethnobotany projects. These contacts lead him to accept a position with the Programa Waimiri-Atroari, an aid program for an indigenous group impacted by a hydroelectric project north of Manaus, where he was responsible for agricultural extension and environmental control. He remained at this position for three years, after which he moved to Florida to begin PhD studies in 1996.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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